BELL TELEPHONE QUARTERLY

SINGLE COPY ~ 50¢ ~

PER YEAR ~ $1.50 ~

OCTOBER, 1932

TABLE OF CONTENTS

A New Way of Splitting Seconds
C. H. Fetter

New York-Chicago Telephone Circuits: Forty Years of Growth and Progress
A. B. Clark

New York's Long Distance Building
K. T. Rood

Ladder Safety Code
H. D. Bender

Large Capacity Manual and Dial Private Branch Exchanges
H. R. White

Recent Changes in Agriculture as Revealed by the Census
R. L. Tomblen

The Bell System's Part in the Work of the International Polar Year
G. C. Southworth

Notes on Recent Occurrences

AMERICAN TELEPHONE & TELEGRAPH CO.
NEW YORK

THE LARGEST TELETYPEWRITER EXCHANGE. (See page 317.)

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

CONTENTS FOR OCTOBER 1932

PAGE

A New Way of Splitting Seconds—*C. H. Fetter* 293

New York-Chicago Telephone Circuits: Forty Years of Growth and Progress—*A. B. Clark* 301

New York's Long Distance Building—*K. T. Rood* 309

Ladder Safety Code—*H. D. Bender* 319

Large Capacity Manual and Dial Private Branch Exchanges —*H. R. White* 329

Recent Changes in Agriculture as Revealed by the Census—*R. L. Tomblen* 334

The Bell System's Part in the Work of the International Polar Year —*G. C. Southworth* 351

Notes on Recent Occurrences 354

VOL. XI NO. 4

PUBLISHED QUARTERLY FOR THE BELL SYSTEM BY THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY. SUBSCRIPTION, $1.50 PER YEAR, IN UNITED STATES; SINGLE COPIES, 50 CENTS

Address all communications to

INFORMATION DEPARTMENT
AMERICAN TELEPHONE AND TELEGRAPH COMPANY
195 Broadway, New York

CONTRIBUTORS TO THIS ISSUE

CHARLES H. FETTER

Pennsylvania State College, B.S., 1917; 1917–1919 Western Electric Company, New York; 1922–1928 American Telephone and Telegraph Company, Development and Research Department, engaged in transmission work; 1928 entered employ of Electrical Research Products, Inc.; 1928–1929 engaged in development of sound recording system; 1929–1931 spent 21 months in England in connection with talking picture studios in England and France.

A. B. CLARK

University of Michigan, B.E.E., 1911; American Telephone and Telegraph Company, 1911–. Toll Transmission Engineer in Department of Development and Research, 1928–. Mr. Clark's work has been largely concerned with toll telephone and telegraph systems.

KINGSLAND T. ROOD

Dartmouth College, B.A., 1918. After leaving the Army, entered the Long Lines Commercial Department, American Telephone and Telegraph Company, New York City, as a member of the Commercial Engineer's section, 1920. Transferred in 1921 to the staff of the Long Lines Magazine, which had just started publication; during the next eight years was successively Assistant Editor, Associate Editor, Managing Editor and Editor. Also assisted in Long Lines publicity work. Publicity Manager, Long Lines Department, 1928–.

HUGH D. BENDER

Ohio State University, B.E.E., 1917. Entered Engineering Department of the American Telephone and Telegraph Company the same year, working on outside plant construction practices and methods. U. S. Army 1918. Department of Development and Research 1919–, engaged in outside plant development problems, since 1921 on tool standardization and development.

HARRY R. WHITE

Massachusetts Institute of Technology, S.B., 1901. Instructor, Engineering Laboratories, Massachusetts Institute of Technology, 1901 to 1903. Mechanical Engineer, Harrison Brothers and Company, Inc., Philadelphia, 1903 to 1909. Mechanical stoker design, Parker Boiler Company, Philadelphia, 1909 to 1910. Since 1910 Engineer, American Telephone and Telegraph Company.

ROBERT L. TOMBLEN

Bates College, A.B., 1914. Worcester Polytechnic Institute, B.S., 1917. Commercial Engineer's Division of the Operation and Engineering Department, American Telephone and Telegraph Company, 1919–1929. Chief Statistician's organization 1929–.

GEORGE C. SOUTHWORTH

Grove City College, B.S., 1914; Yale, Ph.D., 1923; Grove City College, Sc.D. (Hon.), 1931; Assistant Physicist, Bureau of Standards, 1917–1918; Instructor, Yale University, 1918–1923; Information Department, American Telephone and Telegraph Company, 1923–1924; Department of Development and Research, 1924–; Member of the International Radio Telegraph Conference, Washington, 1927. Mr. Southworth's work in the Bell System has been concerned chiefly with the development of short-wave radio telephony.

A New Way of Splitting Seconds

FROM the earliest recorded history of man we have seen evidence of human interest in all sorts of athletic sports. Track and field events were popular in the days of ancient Greece and our present Olympic Games originated there centuries ago. Not only has man always been interested in the purely competitive angle of racing events, but in recent years he has become more and more interested in the performance of the individual with respect to time, in addition to his performance against a suitable competitor. On this basis national and world records have been established in order to classify the performance of the individual in terms of an invariable quantity such as time, where a contestant may compare his own performance either with that of some one who preceded his athletic activities, possibly by years or with other contestants in different localities.

In dealing with this so-called invariable quantity, time, the ordinary method employed of timing a race has been by means of a stop watch. Until several years ago stop watches giving time to a precision of one-fifth second were used, but more recently tenth-second stop watches have been universally employed. In track work, for example, the competitors are started by the firing of a gun. The timers are usually located near the finish line of the race in order to time the finish properly. The timer operates a stop watch at the flash of the gun when the race is started, and operates it again as the runner crosses the finish line. This procedure inherently contains the possibility of three errors; (1) it is practically impossible for a human being to operate a stop watch coincident with the firing of the gun because of the human reaction time involved; (2) it is extremely difficult for a timer to operate his stop watch at the finish of the race coincident with the man

crossing the line, and while this error is probably less than the starting error because the timer has an opportunity to anticipate the finish, it is still very much in evidence; (3) the watch itself by virtue of being built for a precision of a tenth of a second would register the nearest tenth when the timer has operated it. In addition there is likely to be an accumulative error in a stop watch depending upon its adjusted rate as a time piece.

In addition to the question of time performance, judging a race is by no means a simple problem. In a close finish it may be very difficult to decide not only who is first, but also the order of finish of, for example, the first five. A runner may be blanketed by another competitor so that the judge is confused as to which runner he is called upon to judge. As a matter of fact in an important meet not long ago a man who ran second was not placed at all because of the human error in observation.

This state of affairs in regard to track events has been known to exist for some years. Four or five years ago Mr. Gustavus T. Kirby, Chairman of the Advisory Committee of the Intercollegiate Association of Amateur Athletes of America (I. C. A. A. A. A.), who has been interested in amateur sport activities for many years, conceived the idea of photographing the finish of a race in order to determine the proper position of the contestants. He included in this the idea of somehow photographing the time of the contestants as well, and in 1931 he used a motion picture camera which photographed both the finish of the race and the face of an ordinary stop watch. The scheme which he used was that of starting the stop watch before the race was started and recording on the motion picture film a flash of light operated by a contact in the starter's gun. By subtracting the readings on the photograph of the stop watch at the beginning from those of the finish of a race the time could be determined to the nearest tenth of a second.

In the summer of 1931 several individuals at Electrical Re-

search Products were discussing the possibilities of applying to the problem in some way Bell System technical knowledge of precision timing work. This was done in complete ignorance of any progress which had been made along this line and, strangely enough, the same conclusion was reached that was found by Mr. Kirby and his associates, namely, that the only satisfactory method by which a race could be timed and judged was through the use of a high speed motion picture camera arranged to photograph both the performance and the time. Obviously this process would provide a permanent record of each event, which would be of value.

Through a fortunate occurrence in endeavoring to investigate the situation these individuals met Mr. Kirby and discussed the problem with him. They were extremely interested to learn of his activity along this line but felt that the company could make a very important contribution to the improvement of timing apparatus, in that it could build a frequency standard that would permit timing if necessary to one one-hundredth or even to one one-thousandth of a second. The need for such precision in timing in a foot race becomes evident when it is realized that in the faster races, including races as long as a half mile or a mile, a man may run a yard at the finish in a tenth of a second. After discussing this matter with Mr. Kirby, work was begun to develop suitable apparatus for experimental use at the I. C. A. A. A. A. and the Olympic Games in 1932 for which permission had already been granted.

Before design of the apparatus was begun, at least on a model basis, several preliminary requirements as to its operation were established; (1) it was decided that for this use a precision of .01 second would be satisfactory, as such timing is accurate to within three or four inches in the position of the runner; (2) use of the photographic method appeared absolutely essential; (3) it was considered desirable to devise a means of photographing the reading of the clock at the finish of the race to show the actual time of the runner. This meant

that the clock must be reset to zero before the start of the race and be started practically instantaneously with the firing of the gun. The Bell Telephone Laboratories were asked to design a tuning fork generator and a motor driven clock mechanism which would meet these requirements.

In the development of this system it was decided to make two clocks, one associated with the camera in which the time and the finish of the runner could be photographed adjacently on the same film, and another clock which would be started in the same manner as the first but so arranged as to be hand stopped so that one of the timers could use this precision clock as a sort of "glorified" stop watch, by means of which the time, except for human error at the finish, could be read to the hundredth of a second immediately following the race.

The system which has been developed consists primarily of a 200 cycle tuning fork generator which drives a synchronous motor at a speed of ten revolutions per second. The motor shaft is connected to a clock mechanism by means of a magnetic clutch so arranged that the clock dials, which are normally reset to zero and stationary, are set in motion when the starter's pistol is fired.

In designing the clock work itself some consideration was taken of the type of record to be obtained. First of all it was decided to use a standard 16 mm. camera which takes 128 pictures per second. Inasmuch as most of the picture area in the 16 mm. film must be devoted to the action of the contestants, it was decided to use three rotating dials and a fixed hair line in order to obtain the time on the film in the largest possible characters. By the use of rotating dials it was necessary to photograph only a small segment of the entire dial arrangement. Three concentric dials were used. The inner dial rotates at one revolution per second and has one hundred divisions on it. The middle dial rotates at one revolution per minute with sixty divisions, and the outer dial rotates at one

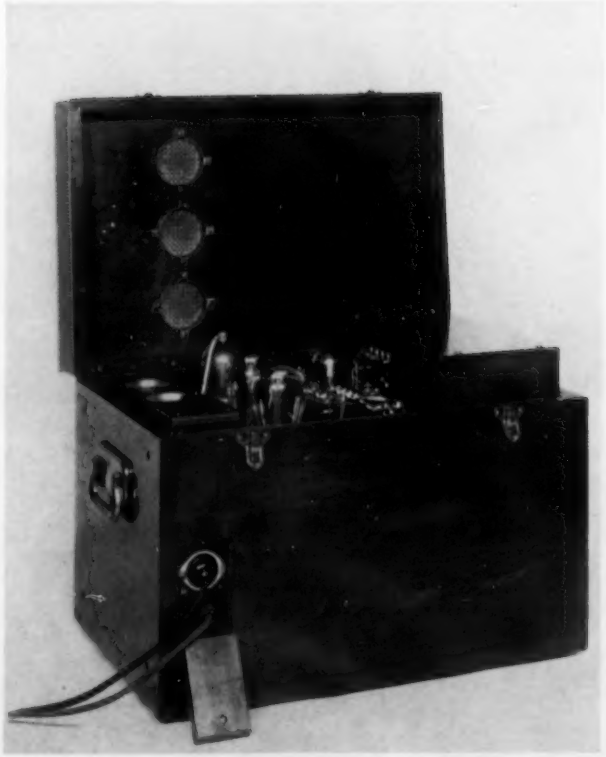


FIGURE 1

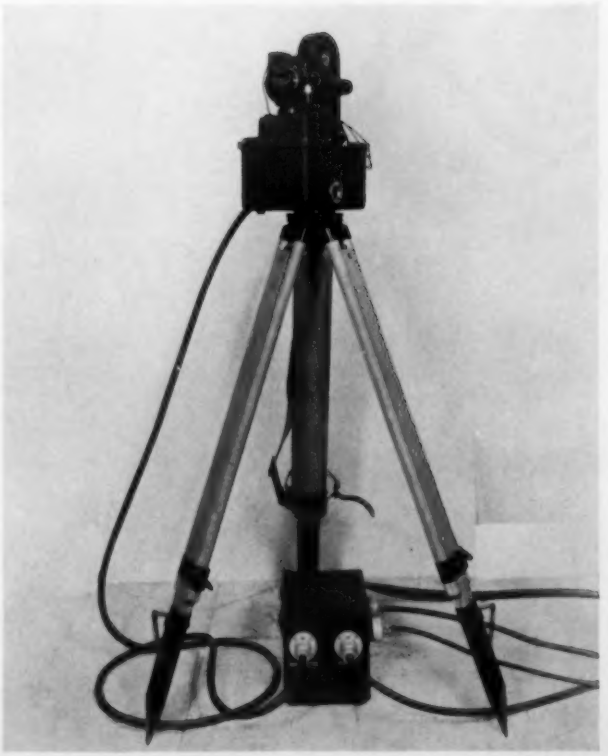


FIGURE 2

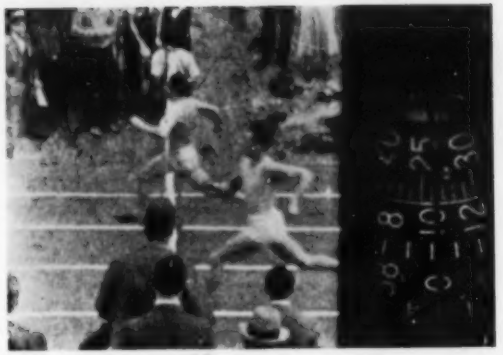


FIGURE 3

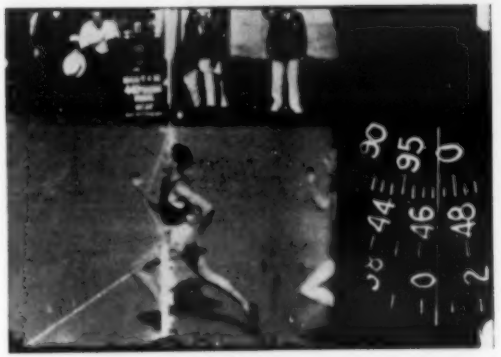
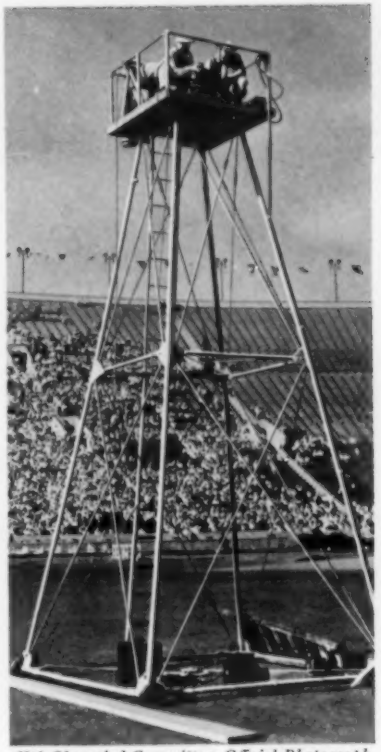


FIGURE 4



Xth Olympiad Committee, Official Photograph.

FIGURE 6

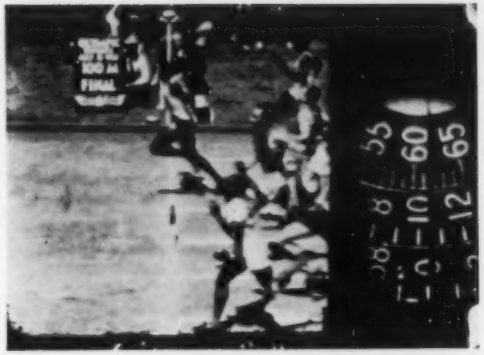


FIGURE 5

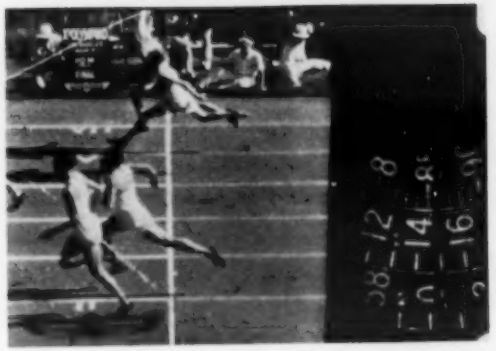


FIGURE 9

revolution per hour with sixty divisions. Thus minutes, seconds and one hundredth seconds can be conveniently read.

Figure 1 shows a photograph of the 200 cycle generator used in this model and Figure 2 shows an assembly view of the camera, clock and a control box designed to provide the necessary power. The whole system is operated from alternating current of 110 volts. The optical system provided to photograph the clock dials can be seen at the left rear end of the main camera lens assembly.

This system was first tried out at the Columbia-Syracuse track meet at Baker Field, New York, on May 14, 1932. Figure 3 shows the first race to have been timed with this system. It was the 100 yard dash in which the time as shown to the nearest hundredth of a second was 10.26 seconds. At the Princeton-Cornell meet at Princeton on May 21, 1932, the system was successfully demonstrated and on June 19, 1932 the apparatus was sent on the Intercollegiate special train which ran from New York to Berkeley, California, for demonstration at the I. C. A. A. A. A. meet there on July 1 and 2.

An example of the results obtained at Berkeley is illustrated in Figure 4, which shows Carr of Pennsylvania winning the 440 yard dash in 46.99 seconds. Even though the camera operates at such high speed, all of the final events on Saturday, July 2, were recorded on less than 60 feet of film. This, of course, is because the camera is operated only as the runners cross the finish line.

At Palo Alto on July 15 and 16 the American Olympic tryouts were held and photographs were obtained of the finish of every heat and final at those tryouts. As an example of how difficult it is to judge a race, Figure 5 shows the finish of the 100 meter final at these tryouts. Metcalf finished first in a time of 10.62 seconds, but there were at least four runners who were not more than a yard or so behind him. Such a grouping of runners shows how difficult it is to judge a close race by eye alone. Note that the camera position is above the finish line

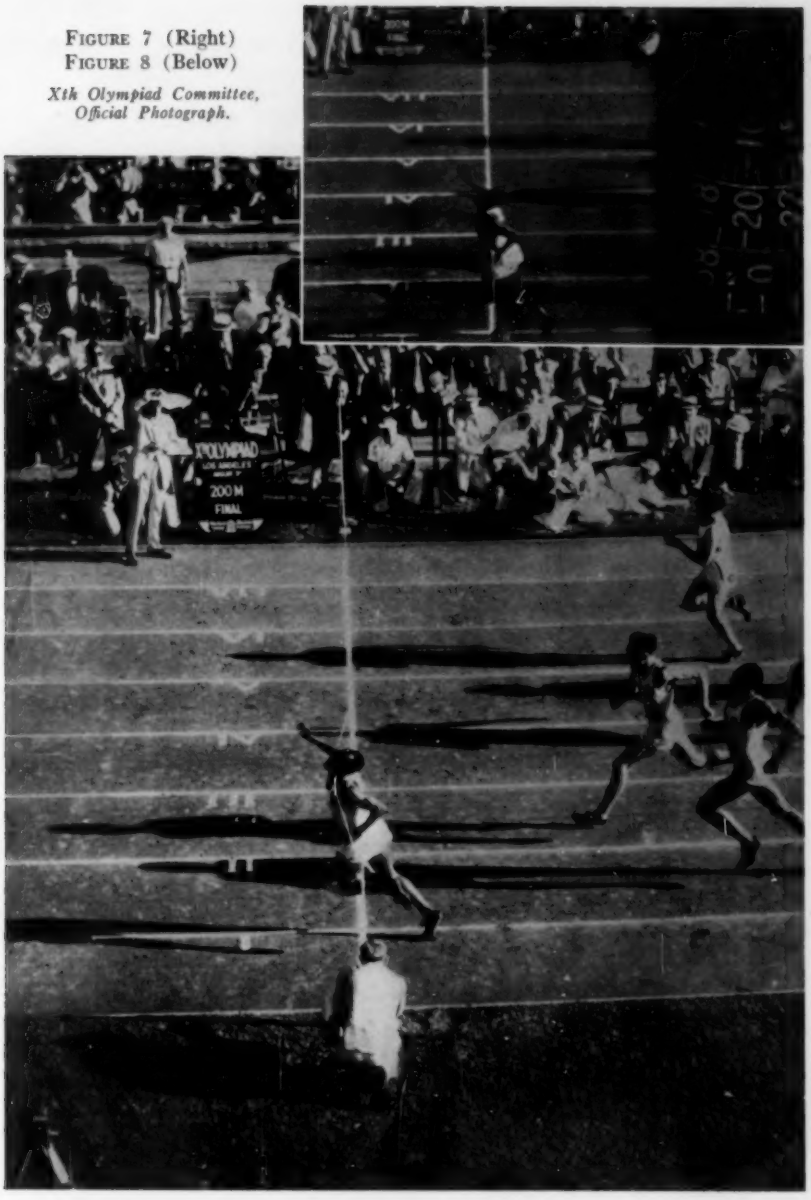
as well as in line with it so that it becomes less difficult to judge properly the finish. At Palo Alto on July 16 the film was shown to the American Olympic Committee and great interest in the timing system used was expressed. As a matter of fact, the committee confirmed one of its own decisions through the showing of the pictures and reversed the fourth and fifth positions in one event because of the camera evidence.

From July 31 to August 7 inclusive this apparatus was in use at the Xth Olympiad held at the Olympic Stadium in Los Angeles, California. A few days prior to the opening of the games some of the pictures taken at Palo Alto were shown to the Olympic Committee, and based upon that evidence the following status was given the timing system: (1) it would be used officially for judging, (2) the hand stopped clock associated with the system would be used as one of the timers of which there were five, (3) it would be used officially for timing the Decathlon.

The camera clock was located 60 feet back from the finish line and on top of a 25 foot steel tower as shown in Figure 6. Throughout the Olympics every trial, semi-final and final was timed. Figure 7 shows Tolan breaking the world's record in the 200 meter run with a camera-recorded time of 21.12 seconds. His official time for this race was 21.2 seconds. Figure 8 is interesting because it shows one of the official photographs taken from the top of the judges' stand for this same race. In the lower left-hand corner can be seen the hand-stopped clock and the timer who is operating it is kneeling in the immediate foreground. Figure 9 (facing p. 297) shows Lord Burleigh of England in fifth place of the 110 meter hurdles. This illustrates how the time of each contestant can be determined as well as that of the winner. This picture is also particularly interesting because it was in this race that Finlay of Great Britain was awarded third place, reversing the decision of the judges who had awarded it to Keller of the United States, before the pictures were seen. The foot of the winner

FIGURE 7 (Right)
FIGURE 8 (Below)

Xth Olympiad Committee, Official Photograph.



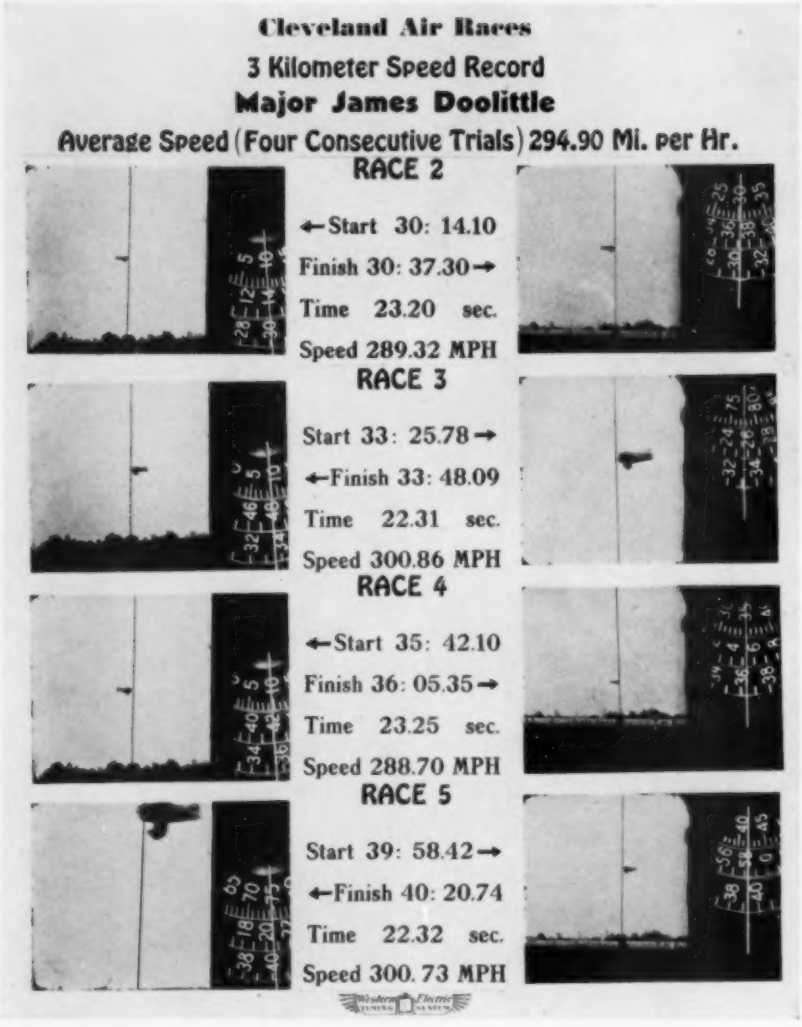

Cleveland Air Races
3 Kilometer Speed Record
Major James Doolittle
Average Speed (Four Consecutive Trials) 294.90 Mi. per Hr.
RACE 2
←Start 30: 14.10
Finish 30: 37.30→
Time 23.20 sec.
Speed 289.32 MPH
RACE 3
Start 33: 25.78→
←Finish 33: 48.09
Time 22.31 sec.
Speed 300.86 MPH
RACE 4
←Start 35: 42.10
Finish 36: 05.35→
Time 23.25 sec.
Speed 288.70 MPH
RACE 5
Start 39: 58.42→
←Finish 40: 20.74
Time 22.32 sec.
Speed 300.73 MPH

FIGURE 10

is just visible at the left side of the picture and Finlay is running in lane 3. Keller of the United States is running in lane 7, the farthest one from the camera. Two other decisions of a minor nature were reversed by the judges after seeing the pictures.

As an example of how the official times compared with the recorded photographed time, figures are given below for some of the Olympic finals:

Race	Official Time	Camera Time	Difference—Official Time Used as Reference
100 Meter Run	10.3	10.38	+.08
110 Meter Hurdle	14.6	14.57	−.03
200 Meter Run	21.2	21.12	−.08
400 Meter Run	46.2	46.28	+.08
400 Meter Hurdle	51.8	51.67	−.13
800 Meter Run	1:49.8	1:49.70	−.10

At a meeting of the International Amateur Athletic Federation after the games were over, this body in an official report praised the use of the timing system and recommended that hundredth-second timing be adopted as a world standard. It also officially invited us to time the Olympic Games to be held in Berlin in 1936.

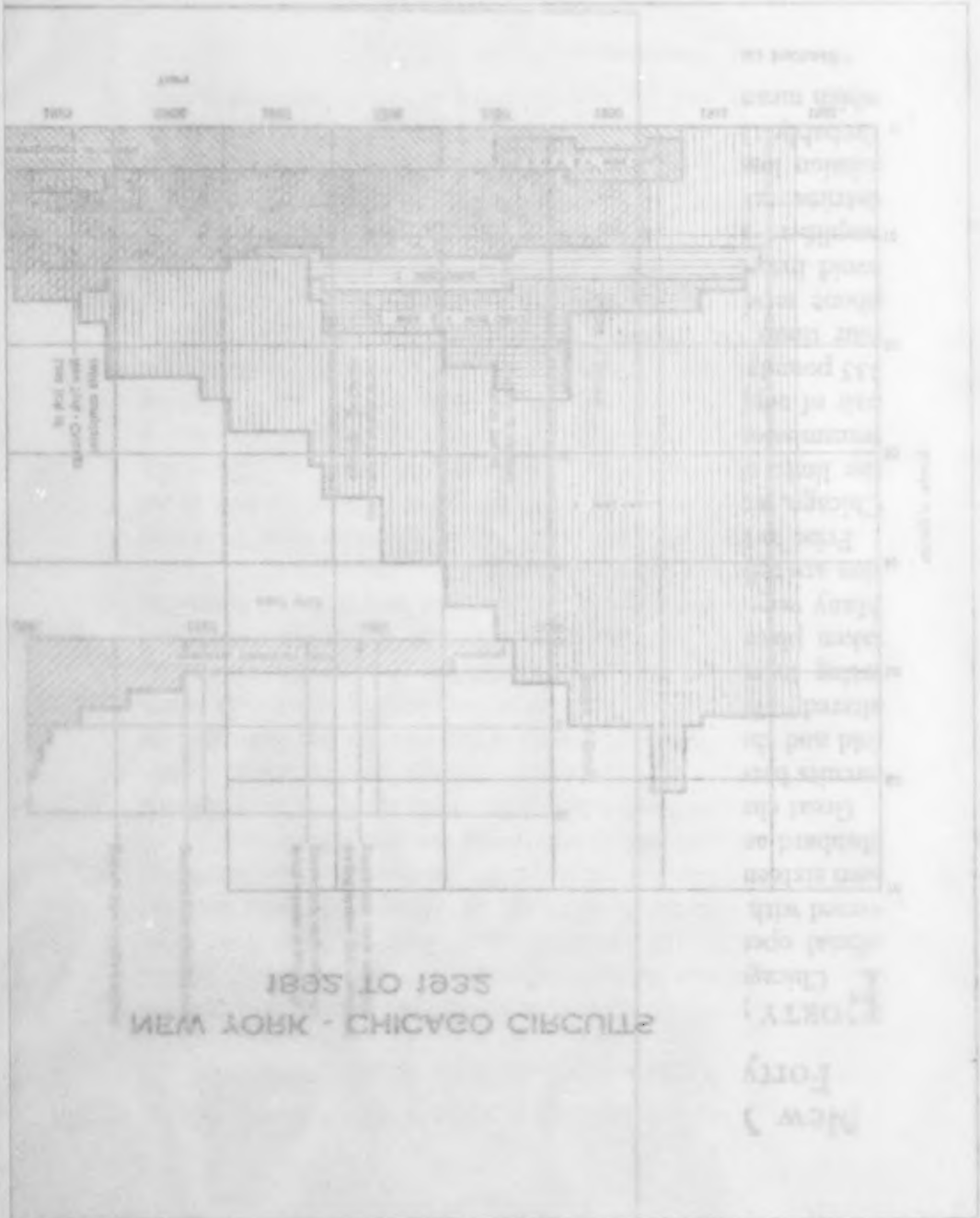
While at the Olympic Games in California Mrs. Amelia Earhart Putnam, having seen and heard of this method of timing, stated that it should certainly be used for airplane races. As a result of this statement the National Aeronautic Association was approached and through the courtesy of Dr. Lewis and other members of the Contest Committee the apparatus was used in collaboration with the official timing means at the Cleveland Air Races from August 28 to September 5 inclusive. In order to time a straightaway airplane speed trial, it was necessary of course to have two camera clocks operating in synchronism from one generator, one to photograph the beginning, a second to photograph the finish of the race. The

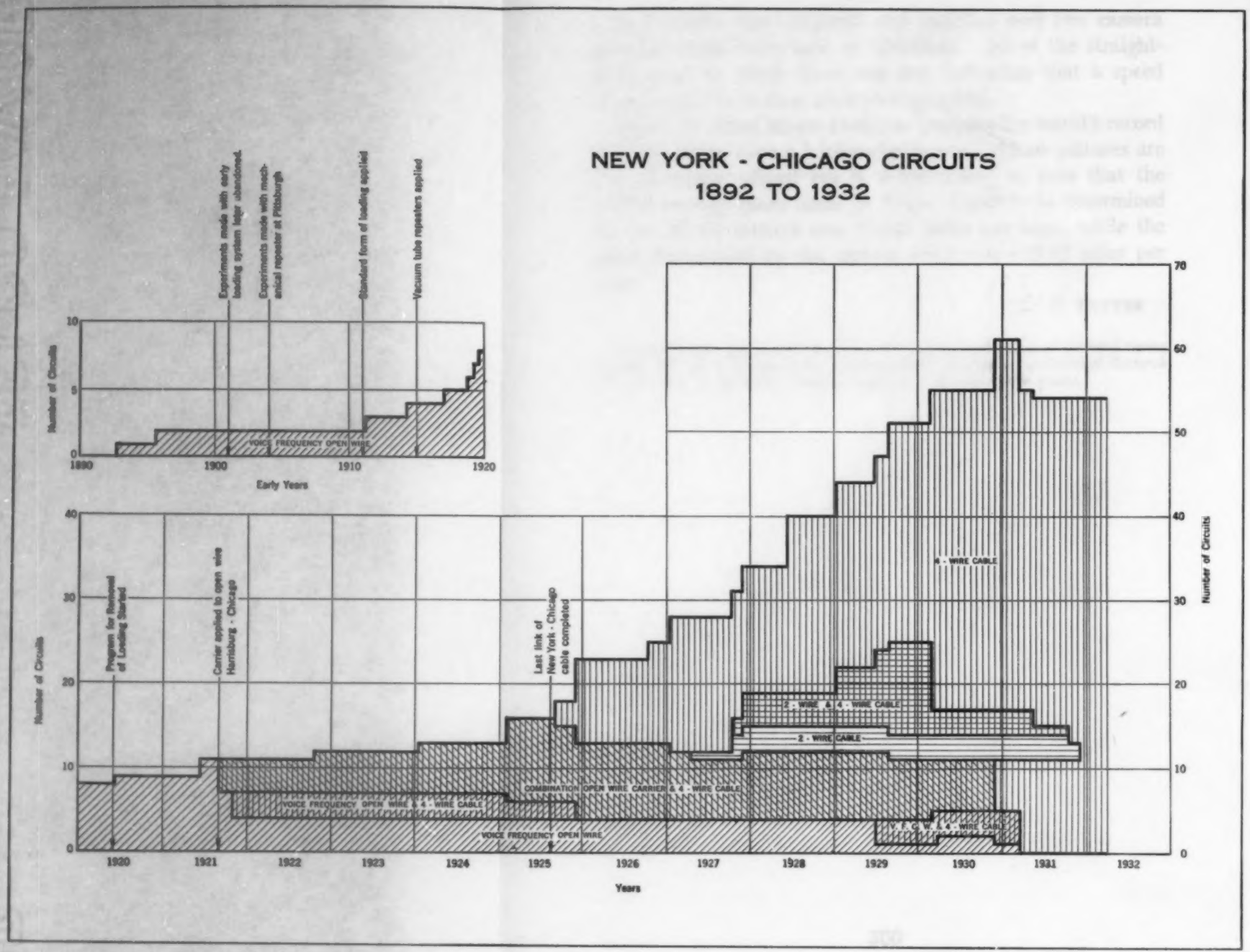
second camera was obtained and modified and two camera operated clocks were used at Cleveland. All of the straight-away races in which there was any indication that a speed record might be broken were photographed.

Figure 10 shows Major Doolittle breaking the world's record for land planes over a 3 kilometer course. These pictures are not, of course, official but it is interesting to note that the official average speed made by Major Doolittle as determined by the official method was 294.48 miles per hour, while the speed determined by the camera clock was 294.90 miles per hour.

C. H. FETTER

EDITOR'S NOTE: *Mr. Fetter has been active in the development of electrical timing systems, and was in charge of the field experiments conducted by Electrical Research Products, Inc., at the recent Olympic Games and at other sports events.*




NEW YORK - CHICAGO CIRCUITS
1892 TO 1932
Experiments made with early loading system later abandoned.
Experiments made with mechanical repeater at Pittsburgh
Standard form of loading applied
Vacuum tube repeaters applied
Number of Circuits
VOICE FREQUENCY OPEN WIRE
1890
1900
1910
1920
Early Years
Program for Removal of Loading Started
Carrier applied to open wire Harrisburg - Chicago
Last link of New York - Chicago cable completed
4 - WIRE CABLE
2 - WIRE & 4 - WIRE CABLE
2 - WIRE CABLE
COMBINATION OPEN WIRE CARRIER & 4 - WIRE CABLE
VOICE FREQUENCY OPEN WIRE & 4 - WIRE CABLE
VOICE FREQUENCY OPEN WIRE
V. F. O. W. & 4 - WIRE CABLE
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
Years
Number of Circuits

New York-Chicago Telephone Circuits: Forty Years of Growth and Progress

FORTY years ago telephone service between New York and Chicago was inaugurated. On October 18, 1892, at the official opening, Alexander Graham Bell at New York conversed with William H. Hubbard at Chicago, whom he had last seen sixteen years before at the Philadelphia Centennial where Hubbard assisted Bell in exhibiting the first telephone.

Great changes have taken place since 1892. The telephone circuits between New York and Chicago have increased manyfold and the physical make-up of the circuits has been greatly altered. With the aid of the accompanying chart it is interesting to retrace the steps, observing the growth which has taken place as well as the changes in the transmission art. Many very important developments in long distance transmission are reflected in this history.

Prior to the construction of the line between New York and Chicago, which was about 950 miles long,[1] 500 miles was about the limit of distance for telephone transmission. To make transmission possible over the practically doubled distance, a pair of copper wires 165 mils in diameter and each weighing 435 pounds to the mile was strung, these wires being more than four times the weight of conductors generally used for telephone service up to that time. Great pains were taken to avoid insertion of lengths of cable in the line since, without amplifiers and loading, such cables would have had a very detrimental effect. Accurate means for measuring the transmission loss of such a line were not available at that time. Probably the overall loss of this line was about 35 decibels, which means that the line delivered at the distant end a little

[1] Shortest cable route is now 862 miles long.

less than one-thirtieth of one per cent of the voice power applied at the sending end. This compares with about 9 decibels for the present New York-Chicago circuits which deliver at the distant end about one-eighth of the voice power applied at the sending end, i.e., the present circuits deliver speech about 400 times as strong. Conversations were, however, readily possible over the original New York-Chicago circuit, between telephones near the main offices in the two cities, the results being considered so satisfactory that additional wires were ordered to be strung immediately. An additional open-wire circuit was soon made available, but the number of through New York-Chicago circuits was not further increased until about 1911. Other circuits were strung, however, which, although normally terminated at an intermediate point, such as Pittsburgh, were connected together from time to time and used for handling business between New York and Chicago.

In 1901 a system of "loading" was applied to the 165-mil New York-Chicago circuits. In accordance with this system, inductance coils were connected serially in the line at intervals of about 2½ miles. When these loading coils were first installed, transmission was materially improved and very favorable comments were received from the users of the service. Then, lightning and atmospheric moisture began to cause trouble. The troubles caused by lightning were soon overcome, but the moisture resulted in serious leakage difficulties, which gradually became worse as more dirt collected at the leakage points. These could not be overcome without radical changes, so that the loading coils were removed from the two New York-Chicago circuits in 1903. Work was continued on the loading method and, as a result, about 1904 loading began to be applied as a regular engineering proposition to lighter gauge open wires, particularly wires 104 mils in diameter, for which circuits the leakage effects were relatively less serious. The loading coils were spaced about 8 miles apart, which spacing remained standard for all future open-wire loading.

Alexander Graham Bell at the Opening of the First New York-Chicago Telephone Line.

While none of these loaded 104-mil circuits went into service as direct New York-Chicago circuits, some were provided as way circuits which were no doubt connected together from time to time to handle New York-Chicago business.

At about the same time that this early work on loading was in progress, other work was also in progress on developing the "phantoming" method. In this method balanced transformers are connected to the terminals of two similar circuits constituting a "phantom" group. By making connections to the mid-points of the line windings of these transformers, an additional circuit called a "phantom" is obtained. Thus a 50 per cent increase in the number of circuits is obtained without stringing additional wires. After overcoming various troubles, not the least of which was the tendency of the circuits to cross-talk unduly into each other, this phantoming method became successful and came into large use on open-wire lines.

In 1904 a telephone repeater using mechanical elements was installed at Pittsburgh and operated on one of the New York-Chicago circuits. The mechanical element consisted of the equivalent of a telephone receiver placed in front of a transmitter. The telephone receiver was actuated by the weak currents from the line, thus causing the carbon grains in the transmitter to be agitated and, therefore, introduce variable resistance in series with a battery. The effect of this was to produce an alternating current roughly resembling the current received from the line in its wave form and, under favorable conditions of adjustment of the device, considerably stronger. Although, in the years which followed, mechanical repeaters were worked more or less regularly on the New York-Chicago circuits and under favorable conditions effected a distinct improvement, the repeater experiments were on the whole not particularly successful, in part due to imperfections in the repeater elements and in part due to incomplete knowledge of the requirements, both of the lines and of the repeater elements, essential to the obtaining of successful two-way opera-

tion as called for in telephone conversations. However, these experiments helped to point the way toward the modern highly successful telephone repeater.

By 1911 the leakage difficulties encountered in loading 165-mil wires had been sufficiently reduced so that the direct New York-Chicago circuits were again loaded. The phantoming method had also been developed in conjunction with the loading method to the point where it became possible to phantom the circuits and load the phantom circuits as well as the physical circuits. With this new setup the overall loss was reduced to about 20 decibels, so that about one per cent of the power applied to the sending end reached the distant end. During very good weather the lines performed even better than this but during rainy weather, however, the results were not so good, although, except under very extreme conditions, the transmission was improved as compared with the earlier non-loaded condition.

The vacuum tube telephone repeater was demonstrated as a great success on January 25, 1915, when service was officially opened between San Francisco and New York, via Chicago. Not only had the repeater element problem been largely solved but much knowledge had been gained of the line conditions necessary for successful two-way operation. To obtain the required line conditions it was necessary to reload the lines with coils of great electrical stability, very accurately spaced, so that the lines were made very uniform. One of the repeater stations was located at Pittsburgh and repeaters were placed at this point for use on the New York-Chicago circuits. By this time another line from New York to Chicago was also in service via Buffalo and repeaters were placed at Buffalo also. Adding these repeaters to the New York-Chicago circuits made a very distinct improvement. During good weather these loaded and repeatered circuits were operated at a loss of about 10 decibels, giving results comparable to the present circuits in volume. These New York-Chicago circuits were, however, materially

inferior to the present-day circuits in clearness of transmission.

During the years which followed the application of repeaters the number of circuits between New York and Chicago increased rapidly, so that about nine were in service in 1920 when the next important transmission improvement occurred. This improvement consisted in removing the loading coils and introducing about twice as many repeaters of a more refined type. A non-loaded open-wire line transmits clearer speech than the same line after loading although without repeaters its volume efficiency is materially lower, particularly during good weather when the loaded circuit is at its best. Consequently, before highly efficient repeaters were available, applying loading to the New York-Chicago circuits gave best results. However, after the repeater had been improved it proved better to remove the loading coils and thus obtain the better clearness of transmission since the repeaters easily overcame the added loss. In fact, due largely to the higher velocity at which speech waves travel over non-loaded as compared with loaded circuits, the repeaters were able to reduce the overall or net losses of the circuits without loading below those formerly obtainable when the circuits were loaded and repeatered.

Removing the loading from the open wires made it possible to apply the carrier transmission method which at that time had been developed to the point where fairly successful results were being secured. The carrier transmission method consists in utilizing bands of frequency above the normal range of frequencies employed for voice transmission, the various frequency bands being separated from each other by means of electrical filters. Thus more communication channels are obtained without stringing more wires. Carrier first came into use on the New York-Chicago circuits during 1921.

About this same time the art of long distance cable transmission had also been developed to the point where cable became suitable for comparatively long distance telephone connections, offering advantages in reliability and economy, par-

ticularly for large groups of circuits. Cable naturally grew from the East, where traffic was heaviest. As the cable replaced the open wires in the Eastern section of the country, combination circuits came into use in the New York-Chicago group, some of these consisting of voice-frequency open wire and cable, others open-wire carrier and cable.

Finally in 1925 the long distance cable was completed between New York and Chicago. In this cable system all of the telephone circuits were obtained by voice-frequency methods using loaded and phantomed circuits. With such circuits a new problem had been found serious due to the comparatively low velocity, which tended to produce pronounced and troublesome echo effects.[2] To reduce this echo difficulty required development of a device called an echo suppressor in which relays actuated by the voice currents block one direction of transmission in a circuit while the voice currents pass in the other direction, thus blocking the echo. The use of cables also brought about an increase in the line loss so that nineteen repeaters were required on the circuits against three on the non-loaded open-wire circuits. This increased loss also introduced another serious problem, that of maintaining the overall efficiency constant. Cable circuits, while kept dry by a lead sheath, remain exposed to temperature variations which cause large changes in their efficiency. If the New York-Chicago cable circuits had been set up simply with the required repeaters but without means for overcoming the transmission variations, service could not have been given for more than a few hours before the circuits would have become useless, either the received currents fading completely out or, if the temperature change happened to be in the other direction, intolerable echo effects or singing taking place. Automatic transmission regulators, therefore, were employed. About

[2] Voice waves travel about 20,000 miles per second over cable circuits of the type now used for long distances. This compares with about 130,000 miles per second for non-loaded cable circuits and about 50,000 and 180,000 miles per second, respectively, for loaded and non-loaded open-wire circuits.

every second or third repeater station is a transmission regulator station in which the repeater gains are moved up and down automatically, thus overcoming the transmission variations.

In long distance cables two types of circuits are provided, four-wire and two-wire. The four-wire or two-path circuit has important advantages in facilitating two-way operation over long distances. During the years which followed the introduction of the first four-wire cable circuits between New York and Chicago, the growth of circuits was largely taken care of by adding more and more of these four-wire circuits. About 1927 some combination circuits were set up, consisting in part of two-wire and in part of four-wire cable circuits. Some other circuits entirely two-wire were also set up. While these circuits gave good results for terminal business, it became clear as the art developed that it would be advantageous to simplify the system by making all long cable circuits alike. At about the same time it also appeared desirable to discontinue the use of open-wires in this circuit group. Thus we have today the whole New York-Chicago group of circuits of a single type, four-wire cable.

It is interesting to compare the present four-wire cable circuits with the original open-wire circuit. Each one of the wires comprising the four-wire circuit weighs 20.5 pounds per wire mile, so that all four wires weigh 82 pounds[3] as compared to 870 pounds for the two wires which comprised the open-wire circuit. Loading coils are employed on the cable circuits spaced 6,000 feet apart while the original open-wire line contained no loading. The cable circuits contain repeaters spaced about fifty miles apart so that on the circuits between New York and Chicago nineteen repeaters are required. The original open-wire line, of course, contained no repeaters. While more complicated, the cable circuits are so designed that in addition to delivering much louder and clearer speech they

[3] If the phantom is allowed for, the weight of copper per circuit becomes only 55 pounds.

do this with much more consistency and freedom from disturbances than did the early open wires.

Thus we have seen an evolution from open wire to cable in which the open wires were first provided on a non-loaded basis, then loaded, then repeatered, and finally restored to a non-loaded basis with more refined repeaters. We have seen open wire gradually superseded by cable even though carrier entered and made it possible to obtain more economical open-wire circuits. At the present time these cable circuits are worked on a voice-frequency basis as was the original open-wire circuit. Developments are now under way which in the future promise other changes. While we do not know what all these changes will be, it now appears quite probable that New York-Chicago cable circuits will some day be obtained by carrier methods and that the wires will be non-loaded and non-phantomed. Thus, in so far as the line proper is concerned, we may return to the simplest form of transmission path, since even more refined vacuum tube amplifiers, electrical filters and other electrical instrumentalities and methods bid fair to make it possible to do a better job without the aid of the loading and phantoming methods.

ACKNOWLEDGMENT

Acknowledgment is made of considerable assistance in preparing this article rendered by many telephone workers and in particular by Mr. L. L. Bouton and Miss M. Darville of the American Telephone and Telegraph Company's Department of Development and Research, and Mr. J. P. Satterthwaite of the Long Lines Department.

A. B. CLARK

New York's Long Distance Building

AMONG the more recent visitors to the new Long Lines Headquarters building at 32 Sixth Avenue, New York, was a group representing the British Society of Mechanical Engineers. Upon arriving in the Long Distance Building they were split up into small parties, one of which went to the Telephotograph Room as its first port of call. There an employee described the processes of transmitting pictures over telephone wires, illustrating his talk by demonstrations of the synchronizing equipment, photoelectric cell and light valve. After listening closely to the explanation one of the guests turned to a colleague: "I say, Doctor," he remarked, "this is really extraordinarily ingenious."

* * *

That was a fairly conservative expression of what most visitors feel on journeying through this twenty-eight story wonderland of modern communication aids. Most of these visitors come from non-technical walks of life. At first they are particularly impressed by the features which the layman can readily appreciate. They are told that the two new portions of the building, rising on each side of the former structure, are supported by mats or rafts of concrete reinforced with steel. They learn that the four stories recently added to the older building do not rest upon it at all, but are suspended above it by means of a huge truss and cantilever system.

They admire the lobby, with its symbolic ceiling decorations of outline glass mosaic, and the auditorium on the main floor. They speed up and down the 450 feet of the building's height in the most modern passenger elevators, operating at a speed of 800 feet a minute. They may peer admiringly into one of the half-dozen recreation rooms, designed with an eye to comfort and good taste, which are provided for operators during their

rest periods. A well-equipped medical unit and a dormitory for operators who come off duty late at night occasion exclamations of admiration. The cafeterias and dining room, the well appointed kitchens, sculleries and bake shops are complete down to the various ceiling treatments for the purpose of deadening sound. Upon entering any of the operating rooms, particularly on hot, humid days in summer, visitors immediately notice the difference in temperature and humidity brought about by the air conditioning system which serves these rooms. Brows and palms which upon entering were dewed with perspiration within two or three minutes become cool and dry.

* * *

While the building is only one part of the entire long distance plant, it is a truly representative part. As visitors go from floor to floor, passing through operating, test and control rooms, practically all glimpse the fact that behind this assemblage of complex apparatus there is a definite and far-reaching purpose. If they can formulate an idea of the immensity of the task of furnishing long distance telephone service to the nation, of the enormous amount of equipment involved and the highly specialized craftmanship required on the part of employees, it is all that can be expected. Telephone men and women will, however, want to go further and inquire into the significance of the building as a part of the Bell System, and its even greater importance as a keystone of the country's long distance wire structure. It is the purpose of this article therefore to attempt to weave the outstanding facts about the building into a comprehensible pattern.

* * *

When the certificate of incorporation of the American Telephone and Telegraph Company was filed at Albany on February 28, 1885, it included this statement: "And it is further declared and certified that the general route of the lines of this association, in addition to those hereinbefore described or

designated, will connect one or more points in each and every city, town or place in the State of New York with one or more points in each and every other city, town or place in said state, and in each and every other of the United States, and in Canada and Mexico, and also by cable and other appropriate means with the rest of the known world, as may hereafter become necessary or desirable. . . ."

Making allowance for the division of traffic between the parent company and the Associated Companies, this statement might well be used as a summary of the purposes of the Long Lines Department. Ever since the department first took definite form in 1900 as the "Department of Long Distance Lines," the providing of long distance telephone message service has been its chief function. From time to time other services have been developed, notably Private Wire Telephone and Telegraph Services, the Telephotograph, the Radio Program Supply, and most recently Teletypewriter Exchange Service. Important as some of these services have already become or are destined to become, the fact remains that the major Long Lines activity is its long distance telephone service. Of the total Long Lines telephone message traffic, approximately 40 per cent originates in, terminates in or passes through the new Long Distance Building in New York City.

To supply the backbone routes of the Bell System's long distance network, the Long Lines Department operates a system of lines interconnecting all sections of the country. Five transcontinental lines cross the plains and the Rockies to form connecting links between the Pacific and Atlantic Coasts. Radio circuits to England, South America, Bermuda and Hawaii extend the talking range from United States telephones more than half way around the world. Similar connections afford service with a dozen liners while at sea.

The wire mileage in the Long Lines plant totals more than 6,000,000 miles. Of this amount, nearly 1,000,000 miles is in aerial wire, and more than 5,000,000 miles is in cable, both

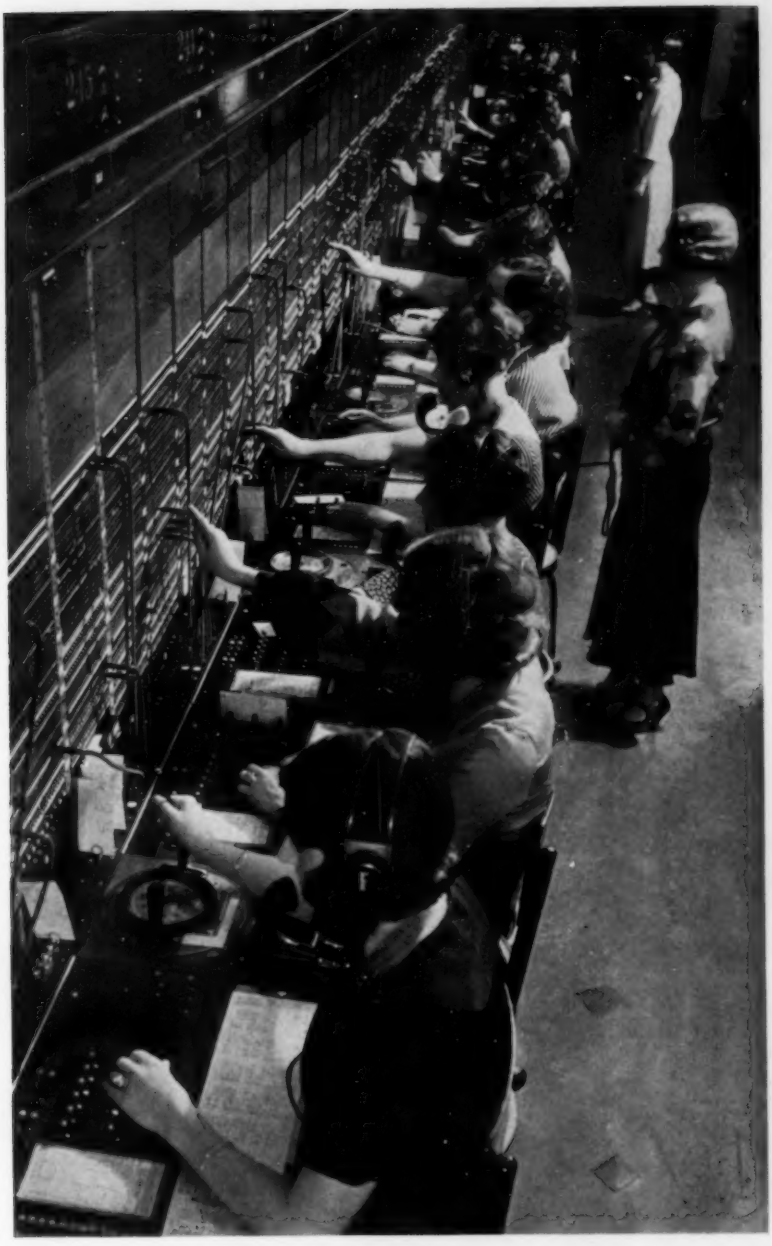
aerial and underground. Measured in terms of sheath mileage, the Long Lines toll cable totals about 15,000 miles. It should be kept in mind that this trunk system can only operate in conjunction with the plant of the local companies. Each call that passes over it begins and ends over Associated Companies' lines and equipment, or those of connecting companies.

With the foregoing paragraphs as a background it is possible to bring the Long Distance Building into more definite focus. It is natural that the great majority of long distance circuits should have at least one terminal in one of the larger cities. New York City is not only the financial center of the country, and the headquarters of many of the leading industries, but also the hub of the great press association wire systems, and of the major broadcasting networks. This explains in part why 3,000 of the almost 10,000 telephone circuits provided for Long Lines use terminate in New York City. A further explanation is to be found in the fact that the metropolis forms a natural communications gateway through which flows a preponderance of the telephone traffic between New England and the remaining forty-two states.

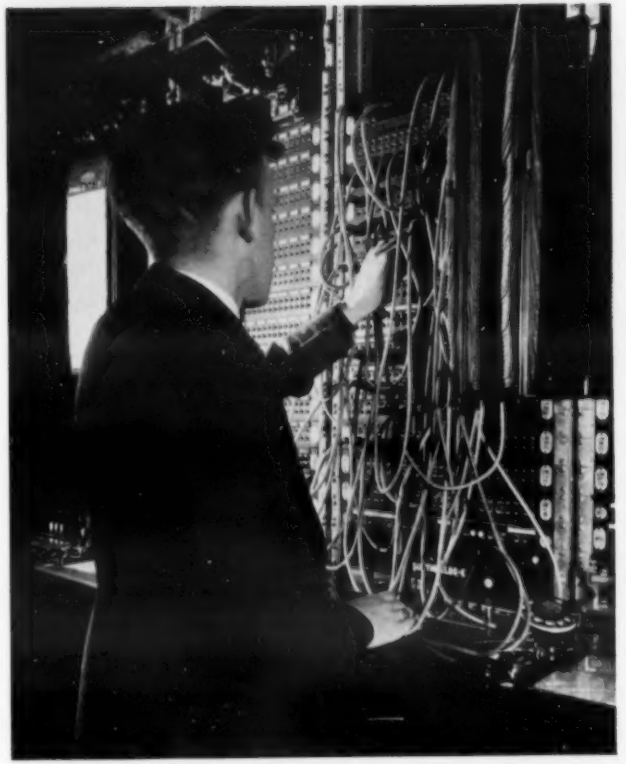
In addition to the circuits which terminate in Manhattan—actually, of course, in the Long Distance Building—there is an additional number of circuits which pass through the building but have their terminals in other cities. Such circuits are the New Haven-Washington circuits, or the Boston-Chicago, the Poughkeepsie-Philadelphia, for instance.

Through the walls of a huge cable vault beneath street level in the building, some 200 cables weave their way underground to a variety of destinations. For example, certain "loop cables" go only to local exchanges. Toll cables, however, proceed to the limits of Manhattan Island, then beneath rivers or the harbor before taking their widely separated ways.

Some remain underground for long journeys, as do the New York-Boston and New York-Washington cables. Others alternately take underground and aerial paths through urban



A Long-distance Switchboard.



A Test-board Expert Keeps Watch for Telephone Circuit Troubles.

A Circuit Patrolman Adjusts Radio Telephone Circuits.

regions and open country respectively. This is the traveling technique of the New York-Chicago cables, for instance.

These practically stormproof voiceways have pushed farther and farther afield during recent years. Today the underground and aerial cable network reaches from Maine to South Carolina, and from the Atlantic seaboard to Northern Wisconsin, Texas and Nebraska. Omaha and Cisco, Texas, are at present the western outposts in the toll cable system.

Still others of the toll cables leaving the Long Distance Building are destined to "fan" their hundreds of pairs of wires into open wire lines radiating to scores of destinations. Out of that swirl of cables, each scarcely larger than a man's wrist, go some 3,000 direct circuits. They range in length from 40 to 3,000 miles and reach approximately 360 cities. The operators in the building complete about 90 per cent of New York's originating traffic over these direct circuits. Traffic to other points is handled by using one of these circuits and asking the distant operator to connect it with a circuit to the desired point. This, of course, makes possible a connection between New York and any other place in the country.

* * *

Having briefly sketched the fortunes of the cables after they leave the Long Distance Building, the time has come to consider the manifold activities which they bring about within the structure. A wholesale idea of their influence can be gained from the fact that on each of 15 floors one or more special phases of the communication art may be seen in action.

Rising from the vault on their way through the building the cables reach "distributing frames" on various floors and promptly lose their identity as lead-sheathed, insulated bundles of copper strands. For there the wires come out into the open to form a perfect maze as they are paired off this way and that, and dispatched in smaller, cloth-covered bundles to a primary testboard where tests can be made and any transmission faults remedied.

The next port of call for the office cable's burden of wires is the phantoming and compositing equipment. This amounts to a fork in the communications road, so to speak. Since many of the pairs of wires are carrying telegraph messages and telephone conversations simultaneously, it is plain that something must be done to separate the two in order that various patrons may receive the particular messages intended for them. Onlookers cannot actually see this magic performed, but they can follow down first one road and then the other for perhaps a new appreciation of electrical sleight-of-hand. Telegraph circuits, for instance, after they have been sidetracked, pass successively through a telegraph line board, telegraph repeaters, an intermediate telegraph board and finally through a telegraph service board. They then return to cables which connect with the offices of brokers, press associations and other subscribers whose business requirements involve the use of this type of communication service.

The telephone signals, having parted company with the telegraph circuits, also submit to a variety of tests, amplifications and general examination in passing through special equipment on the way to the toll switchboards, or to the offices of subscribers who have special leased wires for telephone service.

As a matter of interest it should be mentioned here that the phantoming and compositing equipment referred to above not only separates the direct current telegraph from the voice frequency telephone circuits, but derives "phantom" or extra circuits from the wires. Other methods of obtaining several telephone or telegraph channels from one or two pairs of wires are also employed. It is common practice, for example, for the modern technician with his special equipment to make four pairs of wires yield six telephone circuits or thirty-six telegraph circuits or various other combinations of telephone and telegraph circuits.

* * *

The visitor at 32 Sixth Avenue may be unaware of the prog-

ress of electrical events around him as just outlined, but certain of the results will be apparent to him. In the testrooms he glimpses what appear to be acres of complicated equipment, some of it ceiling-high, and learns that here is where the "circuit patrolmen" or "trouble shooters" keep constant vigil over telephone and telegraph service.

On another floor he stands before a switchboard labeled CLR, presided over by a line of operators. Here he sees the operating practice which accounts for the fact that any long distance call he makes will be completed, on the average, within two minutes. Less than ten years ago the speed of service was 11.3 minutes. The gradual reduction to two minutes has been due in part to the fact that the long distance operator who answers the subscriber's signal not only records the details of his call, but picks up the proper circuit and puts it through without turning this function over to a line operator as formerly was the practice. Thus, CLR takes its initials from the phrase "combined line and recording."

Shortly after leaving the CLR section the visitor finds himself before the Foreign Service switchboard, where labels at various intervals suggest really long distance: "London," "Buenos Aires," "Havana," "Ship-to-Shore." Needless to say, here are the operators who handle all overseas radio telephone calls and those to ships at sea. More than thirty foreign countries, together with a dozen ocean liners figuratively are at the tongue-and-finger-tips of these specially trained girls. Among them these operators speak several languages. Each has before her a chart from which all transoceanic rates may instantly be quoted to the calling party upon request. A bulletin board serves the same purpose with reference to ships. This board, revised daily, shows at a glance which vessels may be reached and at what hours, and whether the lower or higher rate applies.

In calling Buenos Aires the operators actually ring the distant office by radio, but in calling London (through which

Continental points, Asia, Africa and Australia are reached) the operators merely say "Hello, London" on the circuit until the distant operators, who are on duty at all times, answer.

The maintenance and general technical side of this service are on view in the Overseas Control Room. The land terminations of the various radio circuits pass through this room, where technical operators make constant adjustments to compensate for variations in atmospheric conditions, as well as for varying land connections and voices of different speakers.

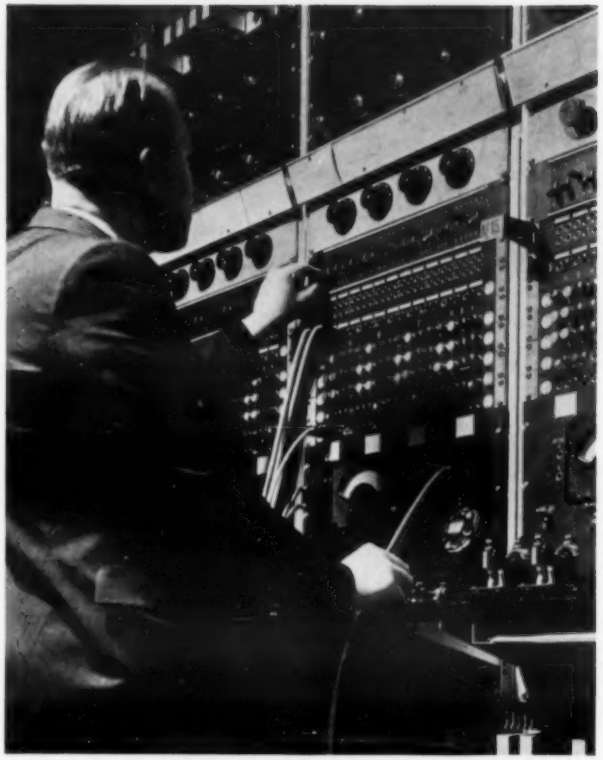
The radio facilities consist of one long-wave and three short-wave channels to England, a short-wave circuit to Bermuda, another which alternates to Brazil and Argentina, and a short-wave circuit to ships at sea. A sixth short wave circuit, to Peru, was opened for commercial service on October 14. The long-wave transmitting station is at Rocky Point, Long Island, N. Y., with the corresponding receiving station at Houlton, Me. All of the short-wave radio facilities are at stations in New Jersey. At Lawrenceville are the transmitters for England, South America, and Bermuda, while at Netcong are the corresponding receivers. For ships at sea there is a transmitting station at Ocean Gate and a receiving station at Forked River.

A radio telephone circuit actually consists of two one-way channels, the voices of the two subscribers reaching their destinations by separate routes and on different wave lengths. These two sides of a complete circuit are merged in the Control Room, on the twenty-fourth floor of the Long Distance Building.

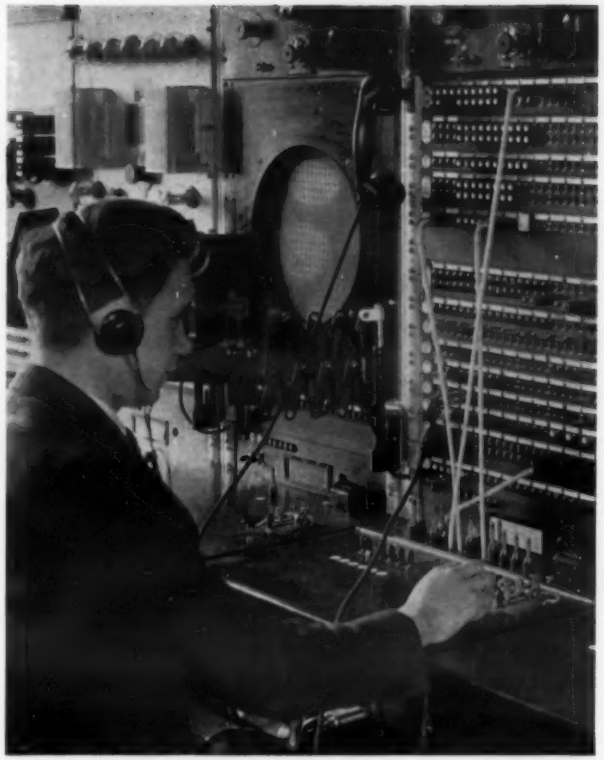
An important piece of apparatus in this room is the privacy device. This "scrambles" the speech before it leaves the central room, to make the conversation unintelligible to any unauthorized persons who may chance to pick up the radio signals, and "unscrambles" a similarly garbled voice from across the ocean.

Another radio control room in the Long Distance Building

THE TRANSOCEANIC SWITCHBOARD WHERE TELEPHONE CONNECTIONS ARE MADE WITH OVERSEAS COUNTRIES AND SHIPS AT SEA.



A Technical Man Keeps Private Wire Telegraph Systems in First-class Order.



A Monitor Sees that Radio Programs are Satisfactorily Transmitted by Wire to Chains of Broadcasting Stations.

represents the nerve center for the gigantic network of long distance telephone wires delivering distant programs to the various stations of the major broadcasting companies. At present the Bell System furnishes to broadcasting companies about 45,000 miles of special telephone circuits. In addition, about 75,000 miles of telegraph and teletypewriter wires are used to co-ordinate the activities of nearly 200 broadcasting stations scattered throughout the country. With programs which may change every fifteen minutes, from dawn until midnight, the demands upon this force and their equipment are of an exacting nature. Changes must be effected with split-second accuracy, emergencies must be provided for—whatever happens, programs must go through.

In another part of the building considerable space is devoted to the latest Bell System communication development—Teletypewriter Exchange Service. At switchboards similar to those already seen, operators swiftly interconnect teletypewriters for sending and receiving messages throughout the country just as telephones are connected to transmit the spoken word.

The arrangements for this service closely parallel those for telephone service. A teletypewriter, of either the tape or page type, is installed in the subscriber's office and connected with the exchange. When he wishes to hold a teletypewriter conversation with another subscriber he signals "Central" and types out the name and address or number of that subscriber. The operator builds up a circuit to the desired teletypewriter and rings the bell on the latter machine. The called subscriber acknowledges—by typing—and the two are connected.

Facilities of the Long Lines for the transmission of pictures by wire have been available for public use since 1925. Stations are located at New York, Chicago, San Francisco, Los Angeles, St. Louis, Atlanta, Cleveland and Boston. A picture may be sent from any one of these stations to any or all of the others. The Long Distance Building houses the New York

telephotograph station, and it is here that the visitor may learn what makes it possible for the "electric eye" to bring camera records across the miles to his favorite newspaper.

* * *

The Long Distance Building, dominating the region it occupies on Manhattan Island, exemplifies a certain spirit and a certain aspiration which impress themselves upon the visitor not only while he is within the structure but long after he has left it. Not long ago another British guest, a member of a commission of four sent to examine Bell System methods of handling long distance traffic, made the building an important part of his investigations. In a paper read before the Telephone and Telegraph Society of London, shortly after his return home, he said in part:

"You have all heard no doubt of the 'Spirit of Service' as applied to American companies. You may have thought it an advertising catch phrase. It certainly is not in the Bell Telephone Service. It is a real, live, active spirit, pervading the business from top to bottom . . .

"Whether a man wants his neighbor in town, or some one in a far-away state, whether the calls come one or ten a minute, the work of the operator is ever the same—making direct, instant communication everywhere possible.

"This is Bell service. Not only is it necessary to provide the facilities for the weaving of speech, but these facilities must be vitalized with the skill and intelligence which in the Bell System have made Universal Service the privilege of the millions. That is the Spirit of Long Distance Telephony in the United States of America."

K. T. Rood

Ladder Safety Code

Editor's Note:

In the Bell System, ladders are a contributing cause in approximately five per cent of all lost time accidents, and have accordingly been given intensive and continuous study in the program for elimination of accidents that for many years has enlisted the attention of various groups throughout the System. The results of accident prevention work in general are perhaps no better illustrated than by what has been done in the case of ladders.

Many of the problems are common to numerous other organizations, and through co-operative efforts with them the Ladder Safety Code has been developed. The following description of the code which was prepared as a report of the Code Committee to its sponsor body, the National Safety Council, and presented to it on October 4, 1932, outlines the more important details and some of the interesting considerations that enter into this type of accident prevention work. It also explains the Bell System's interests in this particular safety program and sets forth some of the benefits that have been realized therefrom.

ACCIDENTS from the use and misuse of ladders was selected as one of the first subjects to justify the inauguration of a safety program of national scope under the procedures of the American Engineering Standards Committee (now the American Standards Association). The selection was based primarily upon the available accident statistics which indicated high frequency and severity rates for this class of accidents in practically all types of industrial and domestic establishments.

Where diversified interests are involved, it is recognized

that the first and one of the most important steps in establishing a constructive safety program, is to prepare a code, or as it may be called, a set of standards which define and outline the best practices that can be devised for the common guidance of all interested parties.

The national program for the elimination of ladder accidents, was initiated when this organization—the American Society of Safety Engineers—accepted sponsorship for the ladder code in 1920 and organized a sectional committee to draft it. In order to insure that all interests of the project were fully represented, the personnel of the committee included representatives of the ladder manufacturers, the lumber industry, employers and employees as ladder users, state regulatory bodies, the insurance interests, engineering and safety societies, and the Federal Government. This resulted in a sectional committee of about 25 members.

Before discussing the work of the code committee, I believe that it will be helpful if we take a few moments at this point to consider some of the more important phases of the ladder situation. A ladder may be defined as an appliance designed for use in ascending or descending at an angle exceeding fifty degrees with the horizontal, usually consisting of side pieces called rails, joined at short intervals by cross pieces called steps.

This definition covers two general classes of equipment—the fixed ladders which are securely fastened in a permanent position on structures such as buildings or water towers, and the portable types of ladders which may be used at various locations. This latter class includes the commercial types of ladders such as extension ladders, step ladders, single ladders, rolling ladders, sectional ladders, and trestle ladders. These portable types are mainly wood products while the fixed ladders are built of wood, metal or combinations of these materials, and are usually built and installed during the construction of the structure of which they form a part.

The ladder industry is fundamentally a wood working in-

dustry, interested in the production and distribution of the portable types of ladders. However, in addition to the factory made product, it is also necessary to consider the "hand made" and "built on the job" ladders which are quite common in the building industry.

In considering ladders from the standpoint of their utility, we find that their field is almost unlimited. There is scarcely an establishment whether it be domestic, commercial or industrial that does not make use of ladders in one way or another. They are indispensable in many classes of work and new uses are constantly being developed as it is learned that makeshifts and substitutes for ladders do not pay. Each use, however, introduces individual problems with reference to handling, transporting or maintaining ladders which may or may not be common to other uses.

The code was drafted in sectional form in order that the subject matter might be presented in an orderly arrangement and be convenient for reference. The sections with a brief outline of their subject matter are as follows:

Section 1 is of a general nature covering the scope and purpose of the code.

Section 2 defines the different types of ladders and has an added objective of standardizing nomenclature.

Section 3 covers the materials that are acceptable for use in ladders and in the case of wood parts it covers timber requirements and permissible defects as a basis for grading ladder stock. This section also includes a classification of native woods on the basis of mechanical properties considered from the standpoint of suitability for use in ladders.

Section 4 outlines proof tests for certain types of ladders with methods of testing.

Section 5 specifies the dimensional requirements for the parts common to different types of ladders. It also covers requirements governing the assembly of these parts.

Section 6 covers the construction features for each type of

ladder such as overall dimensions, spread and slope, locking devices, non-skid bases and all other equipment and features that are special to each individual type.

Section 7 covers the installation of fixed ladders.

Section 8 covers accessories such as cages and landings for fixed ladders.

Section 9 outlines the safe practices that should be followed in the use of the different types of ladders.

Taken as a whole the code represents a set of specifications which outline the standards of performance that are generally acceptable from a safety standpoint in the construction and installation of all types of ladders. Furthermore, it includes recommendations and safe practices for the general use of ladders. The code was approved as a Tentative American Standard and issued during the latter part of 1923, as Bulletin No. 351 of the United States Bureau of Labor Statistics.

You may have noticed that up to this point I have not mentioned "controversy" and "compromise," two of the terms which are associated with the subject. Personally, I feel that these two words do not reflect a true picture of the processes of development of the ladder code. In my own opinion, the discussions that arose in this work were based primarily on differences of viewpoints which are inevitable in development and research work of this type with a group earnestly endeavoring to solve a perplexing problem. Furthermore, I believe that an integration of these various viewpoints resulted from the discussions rather than a compromise, i.e., that through free and frank discussion, the salient features of each view were presented and through these presentations the conflicting viewpoints were modified so that mutual understanding and agreement resulted. We shall discuss later some of the original differences of opinion in connection with the present revision of the code.

While the main objective of the code is to promote safety, its acceptance by all interests offers a number of commercial

and economic advantages as by-products. The most important advantages are:

1. It serves as a background of common understanding between the users, ladder manufacturers and other interests.
2. It standardizes and simplifies the problems of the lumber industry and broadens the field for their product.
3. In the ladder industry it brings standardization and simplification with mass production at lower costs.
4. It serves as a background for standardization to the big user and permits consolidated purchases for use throughout the country.
5. It makes available to the small user a satisfactory product at reasonable cost.
6. It serves as a basis for the establishment of uniform regulations by regulatory agencies.
7. It raises the quality level of the product.
8. Last but not least, it serves as the foundation for further accident prevention work.

A question might well be raised whether these advantages are theoretical or whether they have been actually realized. This can be answered by outlining the experience of my organization—the Bell Telephone System—in their accident prevention work on ladders.

Ladders are necessary and serve an important rôle in connection with the construction, installation and maintenance of the telephone plant. Practically every occupational employee has occasion to use one or more types in his work and practically every automobile truck engaged in plant work is equipped for carrying one or more ladders. The types most commonly used are extension ladders, sectional ladders, step ladders, straight ladders and rolling ladders. When the national code was issued the only types covered by Bell System standards were the rolling ladders employed in the maintenance of central offices and a straight ladder for manhole use. The remaining types, which are largely employed by the out-

side construction and installation forces, were furnished under local arrangements established individually by each operating company of the system.

With the issuance of the code in 1923, steps were immediately taken to prepare detailed purchase specifications for the types not previously standardized. Specifications for extension ladders were issued early in 1924 and those for step and sectional ladders about a year later. While these specifications were based upon the code requirements, they were drafted to cover a definite design and the construction and material features were outlined more fully in order to eliminate all variables and permit the establishment of a thorough inspection routine. All ladders purchased under our specifications are inspected 100 per cent by a trained inspector to insure that all materials and workmanship are equal to or better than the specified limits or requirements.

In addition to the consolidation of purchases which insures competent inspection under standard specifications, there are many other activities which contribute directly to accident prevention in the Bell System. The most important of these that relate directly to the safe use of ladders are:

1. The standardization of plant design.
2. The preparation of standard practices for the construction and maintenance of each type of telephone plant.
3. Safety organizations which investigate, study and recommend conditions or methods to effect improvements in safety.
4. The publication of posters to illustrate safe practices.
5. An educational program for training occupational employees in the most efficient and safest methods of performing their duties.
6. Preparation of safety codes for each class of work.
7. Study of accident data as guide for future developments.
8. The development of improved methods of transporting ladders on trucks.

9. A development program for investigating and trying out new products, designs or processes in advance of their adoption.

10. The preparation of tool instructions to cover use, care and field maintenance, as illustrated by a handbook of 32 pages which outlines in considerable detail specific recommendations for extension ladders.

The safety results obtained from this program may be summarized as follows: For convenience let us assume that 100 represents the frequency index of lost time accidents for ladders per 1000 male plant employees for the year 1923. For 1924 when standards were in effect for extension ladders this index dropped to 70, a reduction in frequency of ladder accidents of 30 per cent. In 1927, after all types were standard, the index was 61 or a reduction of 39 per cent. In 1929, the peak of plant activity, the index was reduced to 40 or a reduction in accident frequency of 60 per cent. Estimates for 1932 based upon the accident records for the first 7 months indicate an index of 26 or a reduction in the frequency rate of ladder accidents for the 10-year period of 74 per cent.

We have followed the ladder situation closely since the code was issued and find that many improvements have taken place. The lumber interests have improved their product through standardization of grading, the ladder industry has effected improvements in production methods and a better product is generally available. Furthermore, the users are paying more attention to their ladder problems and the general trend, particularly in industry, is toward higher safety standards. While all of the benefits mentioned can not be credited to the safety code, it must be recognized that it has proved an important factor in stimulating the endeavors and actions to minimize accidents in which the handling or use of ladders are concerned.

Several years ago the code committee undertook a revision of the code with the thought of bringing it up-to-date and of having the rating changed from tentative standard to standard.

It may be of interest to mention a few of the major topics that came up for discussion in connection with the revision.

One of the first subjects to bring out differences of opinion had to do with the section which outlined a proof test as a means of checking quality of the rails of extension and straight ladders. While this method of inspection is commonly applied to many kinds of materials, it has never been widely used to determine the suitability of timber or similar materials which have such a wide variation in their mechanical properties. Experience indicates that proper grading of the ladder stock followed by adequate visual inspection of the completed product offers a more reliable and a safer basis of insuring quality control. This procedure will at least insure that the method of inspection does not introduce an additional defect in the product, as might occur by overloading a ladder in the test.

The section on material requirements was originally based on minimum dimensions of parts and limiting the timber defects for each part. Inasmuch as it is commercial practice to build certain grades and types of ladders considerably heavier than safe practices require as a minimum, the establishment of such inflexible grading requirements was considered by many as too severe. It was claimed that it resulted in unnecessary waste of material and uneconomical production. The proposed draft includes a complete revision of this section allowing more latitude in the timber grading without impairing the overall safety standards.

The original draft included a number of specific construction or design requirements which were of questionable value from a safety standpoint. For instance, it required a uniform step spacing of 12 inches for all types of ladders. There appears to be no question that uniformity of spacing is desired at all times. In general, the 12-inch requirement is probably satisfactory. However, there are cases where this equipment is designed to reach definite heights where operations are per-

formed and it is entirely possible that a 10-inch spacing in specific cases might prove more acceptable from an overall safety standpoint. This condition was recognized and a more liberal rule was drafted.

Another feature which has occasioned considerable discussion has to do with rung construction. There are opinions that rung joints should consist of a full mortise and tenon; in fact this requirement is included in a state code on ladders. On the other hand, the pocket type of rung construction in which the rung tenon does not extend entirely through the side rail has been used extensively with satisfactory results. In fact, for certain classes of use it appears to offer advantages over the other construction. The principal objection to its use as a standard practice has to do with the difficulty of inspecting the finished product to insure an adequate bearing for the rung. Since the original draft of the code did not cover specific requirements for this feature, the revision recognizes both constructions and outlines requirements for both.

Another feature which causes differences of opinion whenever ladders are discussed is the matter of so-called safety feet to prevent slipping of a ladder on its footing. There are many types available and new ones are constantly being developed. They are generally recognized as a safety feature; however, due to the limitations each type has in the different classes of use and with the many different kinds of footings, no specific recommendations appear appropriate for inclusion in the code. It seems better to leave the decision of selecting safety feet to the different classes of ladder users who are intimately familiar with the types of surfaces encountered for ladder footings in their work and the other special conditions of use.

In general, quite a large number of the proposed changes involve substituting suitable performance standards for requirements which specify methods. The revision involves an additional section on mine shaft ladders proposed by the min-

ing interests and so many minor changes that it was found necessary to rearrange the entire text. Aside from a few last minute suggestions, the revision is complete and it is hoped to submit it for final consideration before the year closes.

It is felt that the acceptance of the revised draft as an American Standard Safety Code will bring the different interests into closer agreement and will intensify their combined efforts toward the elimination of ladder accidents.

H. D. BENDER

Large Capacity Manual and Dial Private Branch Exchanges

SUPPLYING the telephone needs of large business organizations will be recognized as an undertaking of some magnitude when it it recalled that some of the larger business concerns and industrial establishments such as banks, hotels, public utilities, manufacturing plants and similar establishments house thousands of people in a single building. For organization of this kind an efficient communication system is essential, not only for service between the departments within the organization, but also for inward and outward service with the business associates or clientele of the concern.

Recognizing the need for suitable telephone service for this class of business and in accordance with its expressed policy of providing telephone service that shall at all times be adequate, dependable and satisfactory to the user, the Bell System has recently developed two large capacity private branch exchange systems having service and operating features which are particularly adapted to meet the requirements of this service.

In one of these systems all calls are answered and completed by attendants at a manual switchboard. In the other system, employing a combination of manual and dial equipment, calls between the stations and also outward calls to the central office are ordinarily completed directly by means of dials on the telephone instruments. Inward calls from the central office are distributed by attendants to the particular stations desired. In addition, the stations can dial the attendants and arrange to have outside calls, such as toll calls, completed through the manual switchboard if desired.

The manual private branch exchange is coded 606-A and the

combined manual and dial equipment 702-A. The 606-A has a capacity for 5,000 station lines and 700 central office lines and the 702-A a capacity for 9,600 station lines and 900 central office lines. Except for the arrangement of the jacks and lamps in the face of the switchboard, the manual part of the combined manual and dial equipment is the same as the manual private branch exchange and the 606-A switchboard, with the proper face equipment, is employed in both systems. To give some idea of the number of telephone calls that can be handled through these large capacity private branch exchanges, it may be mentioned that they are comparable in size to the central office in cities of from 25,000 to 50,000 inhabitants.

A general view of a 39 position 606-A switchboard which in this case is employed in conjunction with 702-A dial equipment, located in an adjoining room, is shown in Figure 1. A view of a 606-A switchboard used as a separate manual private branch exchange is shown in Figure 2. A general idea of the amount of wiring and cabling required for terminating the station lines and central office lines for a 702-A installation may be obtained from the view of the distributing frame shown in Figure 3. Due to the new features which are incorporated in the 606-A switchboard, an unusually large amount of relay apparatus is required in the cord circuits and on account of insufficient space in the switchboard section it was necessary to depart from the usual private branch exchange practice of mounting the cord circuit apparatus in the section, and the plan of mounting it on separate relay racks was followed. A typical assembly of the relay rack equipment is shown in Figure 4. A general arrangement of the 702-A dial equipment is shown in Figure 5, and a closer view of a selector frame and the apparatus required for miscellaneous circuits is shown in Figure 6. A 702-A private branch exchange power plant is shown in Figure 7.

The more important new features of the 606-A switchboard are similar to those obtained on the larger central office switch-

FIGURE 1. MANUAL SWITCHBOARD USED IN CONJUNCTION WITH DIAL EQUIPMENT.

FIGURE 2. MANUAL SWITCHBOARD USED SEPARATELY.

FIGURE 3. DISTRIBUTING FRAME.

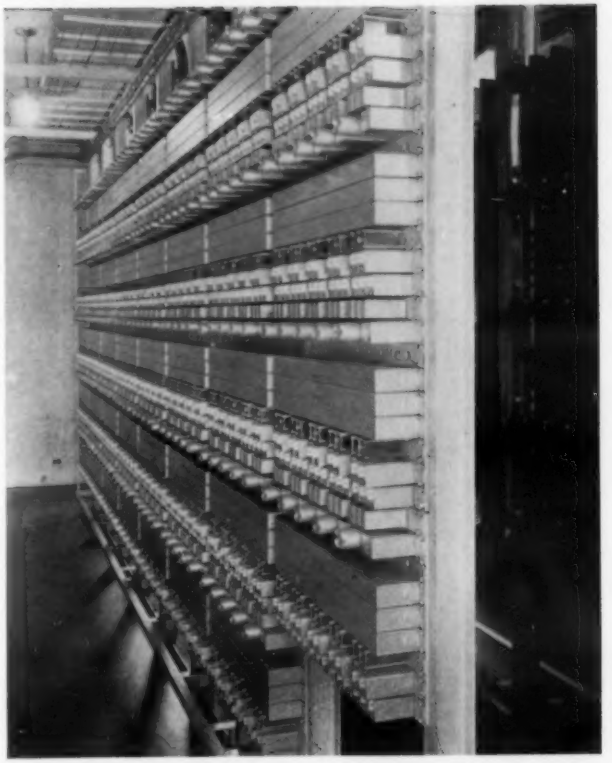


FIGURE 4. CORD CIRCUIT RELAY RACK EQUIPMENT.

boards. As these features make the service more efficient for the telephone users and more convenient for the attendants, it was felt that they would be advantageous to private branch exchange customers requiring systems of these capacities. These new features, which are discussed below, are applicable either when the switchboard is employed separately or when it is associated with the dial equipment, except as indicated.

Line lamps are required with the station lines only when the 606-A is employed as a separate manual switchboard. In this case these lamps are associated directly with the station line jacks which serve both as answering and completing jacks and provision is made for multiple appearances of each line lamp throughout the switchboard. With this arrangement each line can have four lamps, distributed before the attendants as desired. This gives a very convenient method for dividing the work evenly among the attendants and is helpful in keeping the operating forces at a minimum, especially during the night or at other times when there is not enough traffic through the switchboard to warrant keeping all of the positions occupied.

In this switchboard, when a telephone user wishes to attract the attention of an attendant after a connection has been established from one station line to another or from a central office line to a station line, depressing the telephone switchhook once will start a flashing light and an audible signal at the attendant's position to emphasize that her attention is desired. The flashing light and audible signal are stopped as soon as the attendant throws the key to the answering position. This feature is known as "audible flashing recall" and is advantageous to the telephone user, particularly in cases where it is desired to have inward calls transferred from one station to another.

In dial private branch exchanges, on intercommunicating calls, the telephone bells are rung automatically with a two second ringing period and a four second silent period, this feature being known as "machine ringing." A similar feature has

been provided in the 606-A switchboard whereby the telephone bells are rung automatically when the attendant inserts a plug into the jack of the called line, this method avoiding the operation of a ringing key. This feature results in more regularity in ringing the bells at manual installations and gives a uniform ringing arrangement for both the manual and dial parts of the 702-A private branch exchange.

"Audible ringing" is also provided on intercommunicating calls in conjunction with dial private branch exchange equipment, this feature permitting the calling party to hear a ringing tone while the bell of the called station is being rung. A similar arrangement has been incorporated in the 606-A switchboard which gives this feature on calls from one station line to another, thus providing an additional service improvement.

"Idle trunk indicating" is a feature of the 606-A switchboard which is particularly advantageous from an operating standpoint. In this arrangement a lamp is associated with each multiple appearance of all the jacks in a group of central office lines, commonly called central office trunks. A lighted lamp at any attendant's position indicates the lowest numbered trunk in the group that is not in use. When the trunk is seized by an attendant all multiple appearances of the idle lamps are extinguished and the next higher numbered trunk in the group that is not in use will be indicated by the lighting of the associated lamps. As this arrangement facilitates operation of the switchboard, it serves to improve the general telephone service of the system.

The dial equipment, which constitutes the major part of the 702-A private branch exchange, is of the usual step-by-step type employing line finders, selectors and connectors. Telephones within the private branch exchange are reached directly through these switches by dialing the numbers of the stations, which consist of four digits. The attendants are reached through the line finders and selectors by dialing "0." Outside connections are obtained directly through the line finders and

FIGURE 5. DIAL EQUIPMENT FRAMES.

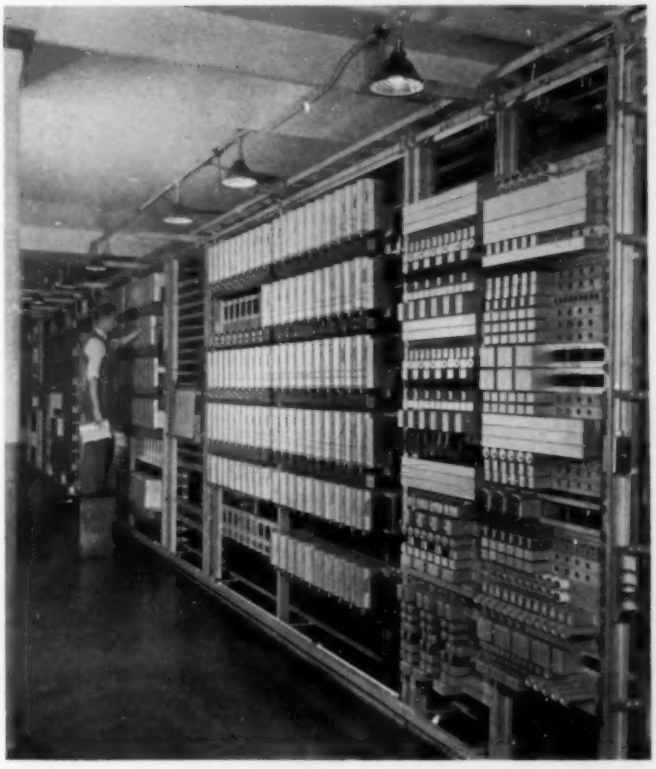


FIGURE 6. SELECTOR FRAME AND RELAY EQUIPMENT FOR MISCELLANEOUS CIRCUITS.

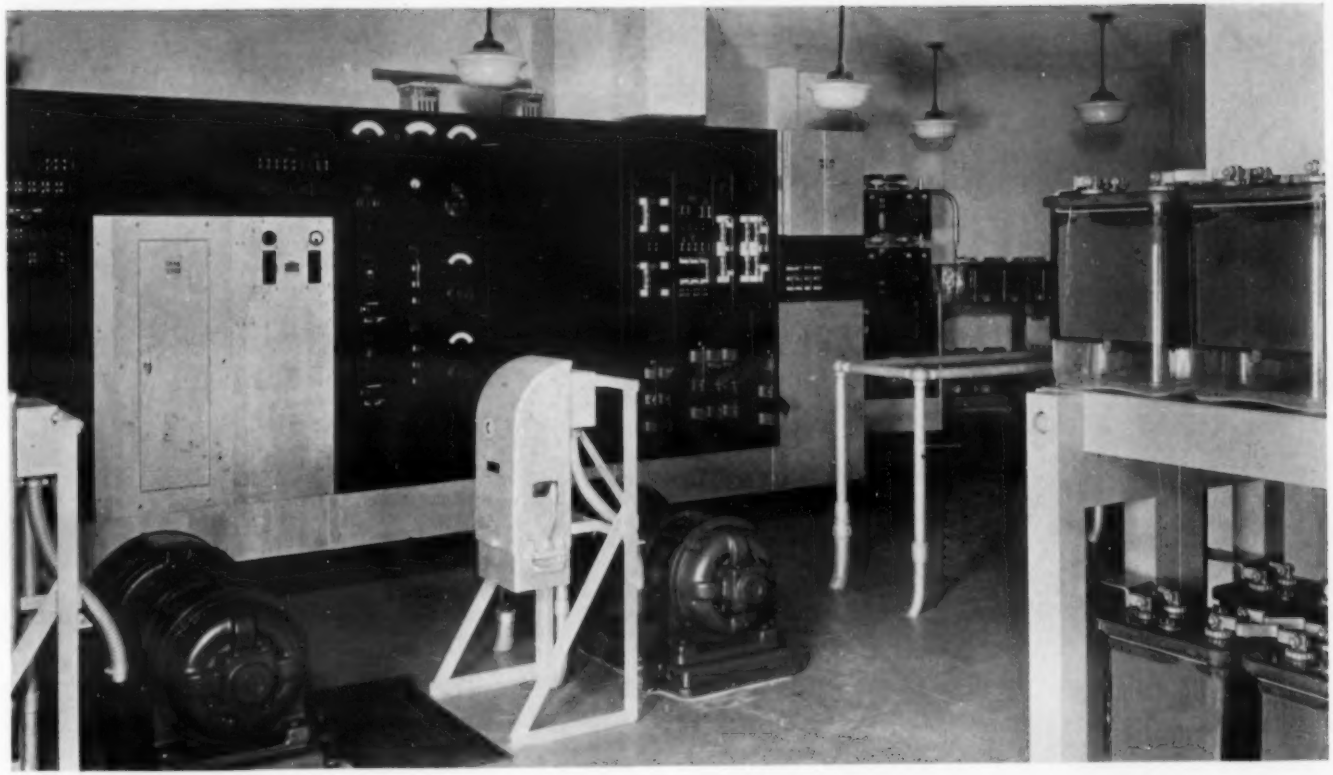


FIGURE 7. POWER PLANT FOR COMBINED MANUAL AND DIAL SYSTEM.

selectors by dialing "9" followed in dial areas by the number listed in the telephone directory or in manual areas by giving the call to the central office operator.

The step-by-step switches of the various kinds and the relay equipment for the miscellaneous circuits are mounted on single-sided frames and these frames, as well as the distributing frame, are uniform in height and somewhat higher than those previously employed in dial private branch exchanges. This design of the framework permits efficient use of the customer's floor space, provides a convenient arrangement for wiring and cabling between frames and facilitates maintenance work.

The power plant may be called the heart of the private branch exchange since it furnishes battery supply, ringing current, tones, signals and maintenance alarms and is, of course, a most important part of these systems. It consists principally of a storage battery, charging equipment, ringing and tone machines and a power board. The charging equipment is operated from a commercial source of power and supplies energy for the private branch exchange equipment and for charging the battery. All units of the power plant are designed to insure continuous and reliable operation of the private branch exchange. They include such features as a liberal sized battery, to provide reserve in case of a failure in the commercial power, and automatic voltage regulation, to maintain the battery voltage within the fixed limits required for proper operation of the switches and relay equipment.

H. R. WHITE

Recent Changes in Agriculture as Revealed by the Census

DURING the period from 1920 to 1930, agriculture in the United States experienced perhaps some of the most revolutionary changes in its history; in fact, it is still in the process of readjustment to a new set of conditions, especially with respect to labor-saving devices and better management. Many of these changes have been vividly reflected in the returns of the 1930 Federal Census of Agriculture. In general, the intercensal decade may be characterized briefly as a period of accelerated mechanization of agriculture, resulting in increased efficiency and volume of production in spite of a diminishing agricultural population.

Naturally the telephone industry is interested in changes in the number and composition of the farm population, and is equally interested in the many developments in agriculture which tend to raise the level of farm profits under normal conditions and which consequently lead to an improvement in the average farmer's standard of living.

According to the recent census enumeration, there were 30,445,000 persons living on farms in the United States on April 1, 1930, comprising one-fourth of the total population. Since the agrarian population constitutes such an important part of the rural market and normally receives an annual cash income from farm production amounting to $10,000,000,000 or more, it is necessary to give serious and continuous consideration to the particular telephone problems which are created by the nature of agricultural pursuits.

Changes in Farm Population

The farm population has been a declining proportion of the total population in the United States for many decades, drop-

ping from 30 per cent to 25 per cent during the past ten-year period, which reflects a reported numerical loss of nearly 1,200,000. There is, however, good reason to believe that the reduction in farm population during the past decade was actually greater than that indicated by the census returns, due to a more thorough enumeration in 1930 than in 1920. The U. S. Department of Agriculture has estimated the annual net loss of farm population between 1920 and 1930 by deducting the natural increase from the net cityward migration; and the result of these yearly calculations indicates an aggregate loss for the ten-year period of over 4,000,000, a figure which probably more nearly represents a true measure of the actual decline in farm population during the past decade than the reduction reported by the census.[1]

Not only are the agricultural workers declining in number, but there are indications that the distinction between urban and rural classes is becoming less clearly defined. According to the 1930 Occupational Census, one out of every eight gainful workers engaged in farming lived in non-farm rural or urban territory. Indeed, the purely rural population may gradually disappear as the agricultural workers tend more and more to live off the farms in towns or unincorporated communities. For with the rapid transportation afforded by the automobile and improved roads, it is now possible for the farm owner and farm laborer to maintain his home in some central community and commute to his daily work. Thus, there has arisen a noticeable tendency away from the long established conception of farming as a mode of living to the modern idea of farming as a daytime business. On the other hand, the tendency for many agricultural laborers to live apart from the farm on which they work is offset to a considerable extent by the fact

[1] Some of the evidence of the superior efficiency of the 1930 census may be found in the article on "Significant Features of the Early Census Returns," which was published in the October, 1930, issue of the BELL TELEPHONE QUARTERLY on pages 275 and 276.

that 1,500,000 of the 10,600,000 workers living on farms are engaged in activities other than agriculture.

Changes in the Number, Size, and Operation of Farms

The number of farms in the United States declined by 160,000 or 2.5 per cent between 1920 and 1930, while during the same period the acreage of all land in farms increased by nearly 31,000,000 or 3.3 per cent. Some farms have been abandoned outright, while others have been absorbed in consolidation proceedings; and a considerable number have disappeared in the engulfing wave of urban expansion and suburban development. Increases in farm acreage have resulted from the exploitation of marginal territory, from reclamation projects, and from the transfer of western lands from range use to crop cultivation.

There was a wide variation in the distribution of the gains and losses in farms and in farm acreage between broad sections of the country. A loss of over 300,000 farms and 32,500,000 acres in farm land occurred in the states east of the Mississippi River, with the principal declines taking place in the industrial states of the East and Central West, although several southern states—Kentucky, Virginia, South Carolina, and Georgia—also lost heavily. By contrast, the remainder of the country experienced gains of nearly 150,000 farms and 63,500,000 acres. In general, losses in farm acreage occurred wherever the number of farms declined, but there were a few outstanding exceptions. East of the Mississippi River, four states—Alabama, Florida, Mississippi, and North Carolina—gained a total of about 57,000 farms but declined in farm land by nearly 6,000,000 acres, while three states west of the Mississippi River—Missouri, Montana, and Idaho—lost about 18,000 farms but increased their land in farms by 10,000,000 acres.

Further evidence of the decline of agriculture in the East is shown by the fact that every state and some 90 per cent of all

counties east of a line passing through San Antonio, Oklahoma City, Kansas City, Des Moines and St. Paul lost farm acreage between 1920 and 1930. The few counties in which acreage increased were largely in recently cut-over forest areas and in sections reclaimed by drainage operations—the most important being the Mississippi-Yazoo and the Mississippi-St. Francis Deltas in Mississippi and Arkansas. West of the Mississippi all the states and a great majority of the counties gained farm acreage, in the main by a large percentage.

The great majority of the farms of the country, 84 per cent in 1920 and 81 per cent in 1930, were farms of between 20 and 500 acres. In all five size groups into which farms between these limits are divided by the census, the number of farms decreased in the country as a whole. On the other hand, the number of farms under 20 acres in size increased 15 per cent between 1920 and 1930, while the farms over 500 acres in size increased by 11 per cent. While the small farms of less than 20 acres have increased in number in two-thirds of the states, this gain has very little agricultural significance. These farms tend to be concentrated in the vicinity of towns and cities and a majority of them constitute the suburban homes of urban workers raising crops for their own family consumption. On the other hand, the increase in the number of large farms and the decrease in intermediate sized farms are significant. This movement toward more large farms has resulted from the more economical operation of the larger unit with mechanical power and more scientific methods. The net result of these changes has been fewer farms and more economical production.

As might be expected, the distribution of farms by size shows a preponderance of small farms in the East and of large farms in the West. Two-thirds of all land in farms under 100 acres in size and over one-half of the farm acreage in units from 100 to 175 acres are in the area east of the Mississippi River, while 64 per cent of all land in farms between 175 and 500 acres and

Region	Changes 1920 to 1930 by Regions							
	In the Number of Farms Operated by				In Farm Acreage Operated by			
	All Classes	Owners	Tenants	Managers	All Classes	Owners	Tenants	Managers
					("000" Omitted)			
New England	− 31,700	− 26,100	− 3,700	− 1,900	− 2,710	− 2,110	− 370	− 230
Middle Atlantic	− 67,600	− 28,000	− 35,800	− 3,800	− 5,530	− 1,250	− 3,630	− 650
East North Central	−118,300	− 72,900	− 40,500	− 4,900	− 6,830	− 4,160	− 1,900	− 770
West North Central	+ 15,800	− 50,100	+ 69,200	− 3,300	+ 8,520	− 7,930	+17,550	−1,100
South Atlantic	−100,400	− 67,100	− 32,500	− 800	−11,410	−10,150	− 610	− 650
East South Central	+ 10,600	− 60,500	+ 71,700	− 600	− 6,070	− 8,730	+ 2,900	− 240
West South Central	+107,100	− 53,900	+160,500	+ 500	+10,450	−11,620	+16,060	+6,010
Mountain	− 2,800	− 23,600	+ 21,300	− 500	+40,110	+23,340	+11,690	+5,080
Pacific	+ 27,600	+ 25,500	− 700	+ 2,800	+ 4,370	+ 4,210	− 240	+ 400
United States	−159,700	−356,700	+209,500	−12,500	+30,900	−18,400	+41,450	+7,850

93 per cent of the acreage in farms over 500 acres in size are west of this waterway.

PERCENTAGE DISTRIBUTION OF FARM LAND ACREAGE BY SIZE OF FARM

Size of Farm in Acres	Unites States		East *		West *	
	1930	1920	1930	1920	1930	1920
Under 20	1.0	0.9	2.0	1.8	0.5	0.4
20–99	14.7	16.1	29.7	29.9	7.5	8.1
100–174	18.3	20.4	29.4	29.6	12.9	15.0
175–499	27.0	29.0	30.2	29.0	25.5	28.9
500+	39.0	33.6	8.7	9.7	53.6	47.6
	100.0	100.0	100.0	100.0	100.0	100.0

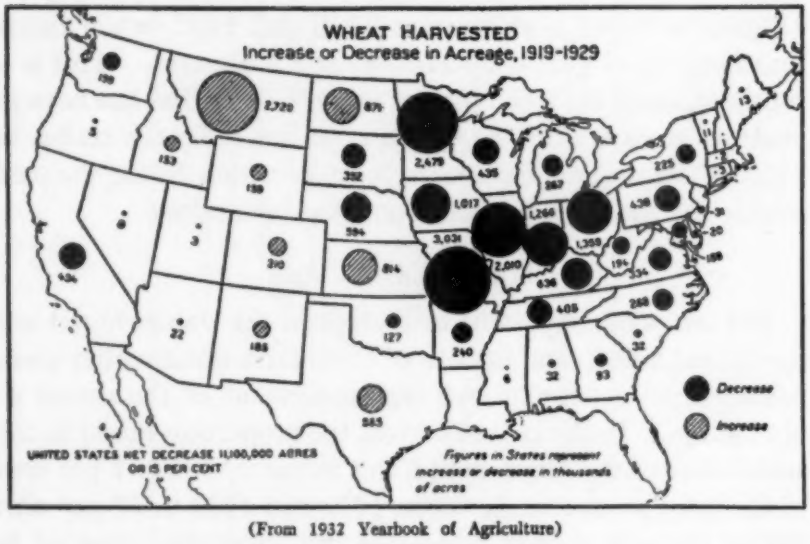
* Mississippi River is taken as the dividing line between East and West.

Closely associated with these changes in the number and size of farms is the altered distribution of operation between owners, tenants, and managers. In the United States as a whole the number of farms operated by owners declined by 357,000 or 9 per cent between 1920 and 1930, while farms tenant-operated gained by 210,000 or 8.6 per cent. This is a continuation of the trend toward more tenancy that has been in evidence since the first report on farm tenure by the census in 1880. The regional changes in farm operation during the past decade are shown in the accompanying tabulation.

MAJOR CASH CROPS

The two most important cash crops in the United States are cotton and wheat, and in both of these farm commodities there has occurred a notable westward movement of the center of production. In the case of cotton, the proportion raised in the states west of the Mississippi River increased from 47 per cent of the total production between 1910 and 1920 to 57 per cent during the past decade. Most of this expansion occurred in the semi-arid plains of western Oklahoma and Texas, where vast areas of cheap range lands, formerly thought suitable only for stock raising, have proved capable of producing low-cost

cotton. During the period 1920–1930 wheat growing pushed steadily forward into the brown-earth belt in the western parts of the Dakotas, Nebraska, Kansas, Oklahoma, and Texas and in the Mountain States from Montana to New Mexico. In fact, practically the entire expansion of wheat acreage in the United States since 1920 has been on the drier subhumid or semi-arid grasslands in the West, where large areas of fairly level surfaces and the less diversified system of agriculture have made it possible to mechanize wheat farming to a greater extent than in most other regions. Indeed, machine methods and large scale operations have been the principal factors in making possible the profitable exploitation of broad areas in these regions of low rainfall, as the tractor and combine are ideally suited to extensive farming operations, and the greater efficiency of production more than offsets any tendency toward lower acreage yields in marginal territory.



(From 1932 Yearbook of Agriculture)

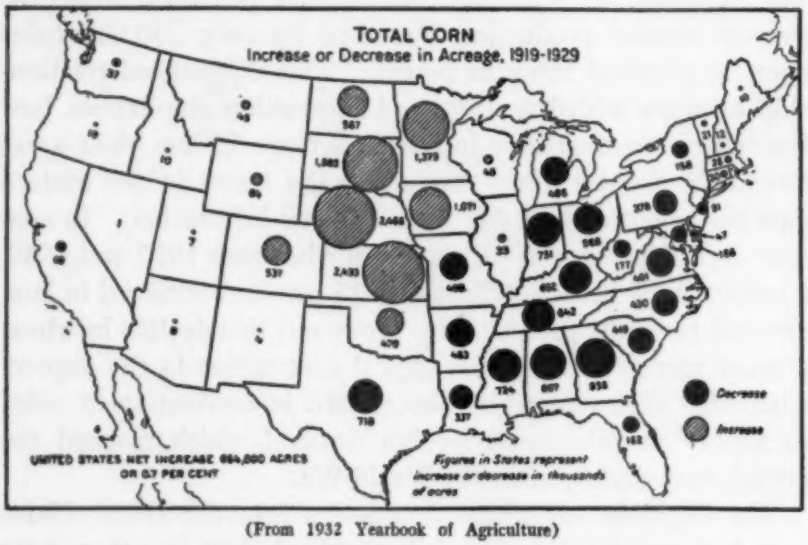
In contrast to the westward expansion of cotton and wheat growing during the past decade, severe contraction in acreage and in production took place in some of the eastern states. In

the old plantation piedmont area including South Carolina and Georgia, in the heart of the territory which has suffered most from the devastation of the boll weevil, cotton acreage was 27 per cent lower in 1929 than in 1919 and cotton production was 43 per cent less between 1920 and 1930 than during the previous decade. In fact, much of the land in the Southeast is now submarginal for cotton, resulting in considerable farm abandonment. At the same time, the concentration of wheat production in the Great Plains region occurred at the expense of the eastern part of the grain belt. The aggregate losses in wheat acreage in six states—Ohio, Indiana, Illinois, Missouri, Iowa, and Minnesota—equalled the total reduction in wheat acreage in the United States between 1919 and 1929, while a gain of 5,000,000 acres in Montana, North Dakota, Kansas, and Texas was offset by losses in other states.

During the past decade the land devoted to raising cotton was expanded by 9,500,000 acres or 28 per cent, while the average annual production increased by only 230,000 bales over the previous ten-year period. This unbalanced relationship between added acreage and production emphasizes how the returns from greatly increased acreage in low yield areas have only slightly more than offset the losses in the eastern part of the cotton belt due to boll weevil infestation. In contrast to the increase in cotton acreage between 1920 and 1930, a reduction of 11,000,000 acres or 15 per cent occurred in land devoted to wheat production. However, this decline in wheat acreage merely represents a logical contraction in the unprecedentedly wide area which was placed in cultivation in order to supply the abnormal foreign demand which marked the period immediately after the World War.

The migration of wheat production into the Great Plains area has permitted a material westward shift in other grain crops, principally corn but including oats and barley. This change has in turn resulted in a marked reduction in the acreage devoted to grain production throughout the South as well

as in the eastern part of the cereal belt. In connection with the increased grain production in the West North Central region, it is especially noteworthy that in Iowa and the southern portion of Minnesota and in the eastern part of South Dakota, Nebraska, Kansas, and Oklahoma the gains in corn acreage very largely replaced losses in wheat acreage during the past decade. In this region the temperature and moisture conditions are better suited to growing corn and the relative yields of corn and wheat are more favorable to corn production. Furthermore, the acreage in oats expanded appreciably in Minnesota, Iowa, South Dakota, and Nebraska, while barley acreage made important gains in Minnesota and the Dakotas. Thus, during the past decade there has been a considerable concentration of grain production in the area including Minnesota, Iowa, and the tier of states extending southward from North Dakota to Texas.


TOTAL CORN
Increase or Decrease in Acreage, 1919-1929
Decrease
Increase
UNITED STATES NET INCREASE 984,000 ACRES OR 0.7 PER CENT
Figures in States represent increase or decrease in thousands of acres

(From 1932 Yearbook of Agriculture)

Between 1919 and 1929 there was a reduction in crop land devoted to raising corn and oats of about 4,600,000 acres each, equivalent to 5.3 per cent in the case of corn and 12 per cent in

the case of oats. The reduction in the production of these feed crops, as well as of hay, reflects the drastic decline in the number of work animals on farms since 1919.

Livestock

In general, the country's livestock population has shrunk considerably during the past decade, especially in the numbers of horses and cattle. The number of horses on farms dropped from nearly 20,000,000 in 1920 to about 13,500,000 in 1930, a reduction of nearly one-third; and the shortage of colts means a continued decline in the horse population. This reduction has been made possible and advantageous by the introduction of power machinery in many routine farm operations—plowing, planting, cultivating, and harvesting. Not only has the substitution of tractors and trucks for horses and mules resulted in greatly increased efficiency of production, but it is estimated that the demand for at least 15 to 20 million acres of hay and grain land has evaporated as a result of this transition from horse power to internal combustion motors. One-half of the reduction in work animals occurred in the North Central states where the mechanization of agriculture has been most widely adopted.

No accurate measure of the change in the cattle, sheep, and hog population between 1920 and 1930 census dates is possible because the counts were not taken at the same time of the year and, consequently, the figures are not on a comparable basis. However, the Department of Agriculture has estimated the number of livestock on farms at the beginning of every year since 1920. These estimates indicate that during the past decade the number of meat cattle declined by about 12,000,000, or 25 per cent, and the number of hogs by 5,000,000, or 8 per cent; while the milk cattle increased by 1,500,000, or 7 per cent, and the sheep and lambs increased by 11,000,000, or 27 per cent. But since there are rather definite and recurring cycles of production in the livestock industry, a direct com-

parison of cattle, sheep, or hog population at the beginning and at the end of a ten-year period does not conclusively indicate fundamental changes in the industry. However, some geographical shifts in production are apparent.

The hog industry has followed corn growing because of the importance of that grain as fodder. There were nearly 7,000,000 more hogs on the farms of the West North Central region in 1930 than in 1920, while losses of 3,000,000 and 7,000,000 occurred in the eastern half of the corn belt and in the South, respectively. The principal gains in sheep population took place in the Mountain States region and in the range states of the Great Plains region extending from Montana to Texas.

There was an increased concentration of meat and milk cattle in the North Central region, resulting largely from the release of cropland formerly required to raise feed for work animals. In this area, the farm animals are more productive per unit of feed consumed than in the southern states and most other parts of the country. Furthermore, as the acre yields of the feed crops and the productivity of the pastures are also higher in the northern states than in the South, the use of tractors in the North has resulted in the production of more milk and meat on a smaller acreage of land.

Although the output of dairy products increased considerably during the past decade, there was very little change in the geographical distribution of the industry. There appeared a slight tendency toward further concentration of dairying in the North Central region which accounted for most of the increase in dairy cattle between 1920 and 1930—with half the total gain occurring in Wisconsin, Minnesota, and Iowa. This region now has more than half the dairy cattle of the country and over 50 per cent of these are in 4 states—Illinois, Wisconsin, Minnesota, and Iowa.

Between 1919 and 1929 the volume of milk produced increased 42 per cent, while the amount of whole milk marketed gained by 76 per cent. A declining amount of butter was

churned on farms during this period, but the quantity of cream sold as butter fat was greater by 122 per cent in 1929 than in 1919. More than 60 per cent of the milk sold is produced in 7 states—New York, Pennsylvania, Ohio, Indiana, Illinois, Michigan, and Wisconsin—while 80 per cent of all cream sold comes from the North Central region. This rapid expansion of the dairy industry in the middle western states has been made possible through the use of machinery that includes mechanical means of feeding, milking, and cream separating.

Practically the same situation obtains in the poultry industry as in dairying. The number of chickens sold in 1929 was more than double the corresponding figure in 1919, while the number of eggs marketed was 93 per cent greater in 1929 than in 1919. Here again, the preponderance of production was in the North Central region which accounted for over half the total production. The heavy increase in the volume of dairy and poultry products is significant as indicating the greater importance of these foods in the changing American diet.

Farm Machinery and Facilities

The transition from horse power to mechanical power in agriculture, although starting about 25 years ago, has shown its most striking progress since 1920. In terms of horsepower the average farmer is four or five times as efficient as he was scarcely a decade ago. One man in the wheat belt with a combine can harvest as much as five or six men could ten years ago, while the cotton farmer in Texas, with tillage implements and harvesting machinery, can attend to as much cotton acreage as six or eight planters in the old South. Along with this development has gone an increase in the average size of farm.

Montana presents a typical example of the change taking place in agriculture in the grain growing region as a result of the rapid mechanization of farming operations. The number of farms declined by over 10,000, or 17.5 per cent, between 1920 and 1930, while the acreage of all land in farms increased

by 9,600,000. The average number of acres per farm increased from 608 to 940 during this period, the number of farms over 1,000 acres in size increasing from 5,622 to 10,501. Farm population declined by over 21,000 or 9.5 per cent, and work animals on farms decreased by 220,000 or one-third. Meanwhile, the acreage devoted to the raising of wheat increased from 1,700,000 acres in 1919 to 4,420,000 in 1929 and the production jumped from 7,800,000 to 40,560,000 bushels. All other grain crops increased in volume, particularly oats and barley. Thus, greatly increased crop production per unit of human and animal labor was accomplished through the application of machine methods and large scale operations.

Every state had more automobiles, motor trucks and tractors on farms in 1930 than in 1920; in many regions the gains were very considerable. During this ten-year period the number of farms reporting automobiles increased from 1,980,000 to 3,650,000, while the farms with motor trucks increased by 714,000 or 540 per cent and the corresponding gain for tractors was 622,000 or 270 per cent. Many farm lands classed as inferior in the horse age because of their remoteness from the railway shipping point, from the improved highway, or from the farmstead have had their accessibility, and hence their economic productivity, very much increased by the introduction of the tractor, the truck, and the automobile. The accompanying tabulation shows the regional distribution of the decade gains expressed as a percentage of all farms reporting specified farm machinery and facilities. In addition, there has been a very material increase in supplementary machinery used for farm work, for which the basic power is supplied by the electric motor and the stationary gas engine; but comparable data are not available by which to measure the exact degree of gain since 1920.

Another development closely associated with the increased mechanization of agriculture has been the marked decrease in farm expenditures for feed and labor. The principal declines

in expenditures for feed occurred in the North Central, the West South Central, and the Mountain regions, where the percentages of decline—averaging 30 per cent—corresponded very

PERCENTAGE OF FARMS REPORTING SPECIFIED FARM MACHINERY AND FACILITIES, BY REGIONS, 1920 AND 1930

Region	Automobiles		Motor Trucks		Tractors		Dwelling Lighted by Electricity		Water Piped into Dwelling	
	1930	1920	1930	1920	1930	1920	1930	1920	1930	1920
New England	60.5	25.7	26.6	4.7	10.5	1.4	43.0	15.3	64.0	47.9
Middle Atlantic	71.0	35.2	30.7	4.8	21.5	3.1	31.9	14.1	38.0	23.3
East North Central	79.7	47.3	19.5	2.3	24.7	5.1	21.0	10.5	21.9	12.4
West North Central	82.6	57.6	15.7	2.9	26.5	8.4	13.2	8.9	16.2	9.8
South Atlantic	42.1	16.2	8.3	1.3	4.2	0.9	6.1	3.9	6.3	3.3
East South Central	30.2	7.8	4.1	0.5	2.1	0.5	3.0	2.1	2.6	1.5
West South Central	45.6	17.4	8.4	0.9	5.7	1.8	3.7	1.9	8.0	4.9
Mountain	67.7	37.6	21.8	2.9	18.0	6.5	20.4	10.3	20.0	10.8
Pacific	75.1	47.2	23.9	4.6	20.9	7.5	52.9	19.3	59.8	41.8
Unites States	58.0	30.7	13.5	2.0	13.6	3.6	13.4	7.0	15.8	10.0

closely with reductions in the number of work animals on farms. Reductions in expenditures for farm labor amounted to $135,000,000 or 30 per cent in the North Central area and to $37,000,000, or 25 per cent in the West South Central states —regions where labor-saving appliances and machine methods have been most widely adopted during the past decade.

VALUE OF FARM PROPERTY AND AMOUNT OF MORTGAGE DEBT

The reported value of all farm property—principally land and buildings but also including implements and machinery and livestock—declined by nearly $21,000,000,000 or 27 per cent between 1920 and 1930, reflecting the drastic decline in the general price level which took place between those years. Over three-fourths of this reduction occurred in the North Central group of states, while the South also suffered relatively heavy decreases. Only two states of agricultural importance registered any considerable gains in the value of farm property,

and these—Florida and California—experienced land booms during the decade.

The proportion of the total number of fully-owned farms which were mortgaged increased from 35.5 per cent in 1920 to 39.3 per cent in 1930. At the same time, the financial burden on the encumbered farm grew heavier, since the average amount of mortgage debt per fully-owned farm increased by $210 or 6 per cent during this period of radically reduced farm values, while the value of land and buildings on these farms declined by $3,500,000,000, resulting in an increase in the ratio of mortgage debt to farm value from 29.1 per cent to 39.6 per cent. However, so far as the farmer's purchasing power is concerned, offsetting factors to the increased portion of the farm income required for mortgage payments were the increased proportion of land available for cash crops and the reduced expenditures for labor and feed.

The ratio of mortgage debt to farm value in 1930 varied greatly among the several states, ranging from 27 per cent in Florida to 50 per cent in Wisconsin. When geographical areas are considered, the North Central group of states showed the greatest increase and the highest level in the ratio of debt to value, advancing from 28 per cent in 1920 to 44 per cent in 1930, while the Pacific region experienced the smallest change and had the lowest ratio in 1930 of all areas, with the ratio increasing from 30 per cent to 32 per cent during the decade.

Co-operative Marketing

In the marketing of agricultural supplies in the United States during the past decade there has been evidence of a much stronger tendency toward co-operation for the purposes of selling farm products than for the purchase of supplies. Whereas the value of farm supplies purchased through co-operative channels amounted to only $125,000,000 in 1929, the value of farm products similarly sold was nearly $900,000,000. However, the former item represented an increase of 48 per

cent over the corresponding 1919 volume of business, while the growth in co-operative selling during the ten-year period amounted to only 24 per cent.

With few exceptions—notably in Michigan, Kansas, Nebraska, and the Dakotas where large decreases occurred—there was a general increase in the value of farm products sold during the past decade through co-operative associations; many states showed considerable gains in this item, especially Wisconsin, Minnesota, Iowa, and Missouri in the dairy region, Florida in the South, Oklahoma and Texas in the Southwest, and California and Washington on the Pacific Coast. Similarly, an increase in the value of farm supplies purchased by co-operative methods between 1920 and 1930 was reported in the great majority of states—the principal exceptions being Kansas, Nebraska, and the Dakotas—while sizable gains were recorded in several states, among which were New York, Ohio, Michigan, Missouri, California, and Washington.

Significance of the Improved Farm Market from the Standpoint of the Telephone Industry

Several developments in agriculture during the past decade, including such factors as the tendency toward larger farms, heavier investment, greater use of machinery, and more widespread education, have combined to improve the farm market from the standpoint of the long pull, although progress may have been temporarily retarded by the depressed conditions of the moment. In fact, there is direct evidence that, associated with the greater efficiency in agriculture realized through the increased use of machinery, there has been a material betterment in living conditions on farms resulting from the more widespread adoption of modern conveniences. For example, the number of farms reporting water piped into dwellings increased from 644,000 in 1920 to 994,000 in 1930, while the farms with dwellings lighted by electricity increased by 390,000 or 86 per cent over the number served either by electricity

or gas in 1920. While the figures for these items vary widely between regions, substantial progress over 1920 has been realized in all sections of the country.

Telephone usage for social purposes in rural areas is fundamentally important, while the farmer's marketing problems require efficient service for communication as well as for transportation. With the increase of standardized grades for agricultural products and with the speeding up of the distribution processes, the greater importance of the telephone for toll as well as for local usage in connection with efficient marketing of farm products will become more and more apparent. Constant co-operation between the telephone industry and the farmer in working progressively toward further extension of telephone service on farms is essential to meet adequately the peculiar requirements of the farm market.

R. L. TOMBLEN

The Bell System's Part in the Work of the International Polar Year

THE year following August 1, 1932, has been designated as the Second International Polar Year. During this period interested scientists throughout the world will make a concerted effort to obtain a large amount of information on such phenomena as the aurora borealis, earth currents, and the motion of the earth's magnetic poles. In order to study these effects at close range, expeditions have been sent into the polar regions by many of the leading nations. A group from the United States is at Fairbanks, Alaska. One from Canada is at Chesterfield Inlet which is near the magnetic north pole. A number of European nations have parties in Northern Europe. The Soviets have inaugurated an especially ambitious program covering several fixed stations as well as special cruises.

The First International Polar Year took place just fifty years ago. It was participated in by even larger groups than will be active this year. It was in this connection that the ill-fated Greely expedition was sent into the Arctic by the United States Government. It may be remembered that due to the failure of two different relief expeditions, Lieutenant Greely (now General Greely of Washington, D. C.) and his party of twenty-five men were left in the arctic for three years with provisions barely sufficient for two years. During this time they advanced to the northernmost tip of Greenland and explored a large part of Grinnel Land, very painstakingly collecting a large amount of valuable scientific information enroute. As relief failed to appear, the party retreated to Smith Sound where they spent their last winter. The following June the seven of the party who had survived the starvation and exposure were rescued by Commander Schley of Spanish Ameri-

can War fame. With true scientific devotion, the men had carefully preserved their records and data.

This year's study will differ somewhat from that of fifty years ago in that it will be devoted more to the electrical state of the earth than to geography. Consequently, there will be very important but possibly less spectacular work to be done in the lower latitudes. For instance, special observations will be made at Hauncayo, Peru, which is located on the magnetic equator. Other work will be done at Watheroo, Australia, which, roughly speaking, is located on the opposite side of the earth from America. A phenomenon which will receive special study will be that of earth currents. It is in this connection that the Bell System will make observations.

As many telephone and telegraph people know, there are occasionally times when abnormally high currents flow in the crust of the earth. This is almost certain to be the case on nights when the aurora borealis is seen. These currents sometimes interfere with service on grounded Morse telegraph circuits. It is perhaps less generally known that the short-wave transoceanic radio-telephone circuits are also adversely affected at times of aurora. Here the effect frequently leads to several hours of lost time and occasionally longer periods. It is interesting to know that at such times the long-wave radio-telephone circuit may actually be improved. It is for these practical reasons as well as the broad interest in the advancement of science that the Bell System is taking part in the work of the International Polar Year.

Earth potentials are being measured at four points in the United States. One is at Houlton, Maine. Another is at New York City. A third is at Wyanet, Illinois, while the fourth is at Tucson, Arizona. Measurement is accomplished by connecting recording voltmeters into telegraph circuits grounded at both ends. These instruments make a continuous night and day record on long strips of paper of the voltage difference prevailing between the two ends. Several hundred volts have on

occasion been recorded on a line a hundred miles in length. Simultaneous records made at each of the four points on two lines running respectively North and South and East and West give an idea of the magnitude and direction of the flow of current in that region. In order that the effects produced by nature may not be masked by those of man-made origin, the connections to earth are located as far as possible from industrial centers where trolleys or other sources of vagrant currents may originate.

Much progress has been made in the methods of measuring terrestrial effects since the last polar year. In particular, the scientist has a useful ally in radio. Both radio echoes and the angles at which distant radio signals reach a station strongly indicate the existence of an electrically charged layer or atmosphere, a hundred miles or so above the earth. This is exactly what scientists hypothecated to explain the aurorae and certain characteristics of the earth's magnetism even before the time of Marconi. It is expected that with the new methods available other facts of nature will be discovered which may be associated with the knowledge already at hand and assembled as important pieces in our jig-saw puzzle picture of the universe about us.

G. C. SOUTHWORTH

Notes on Recent Occurrences

OVERSEAS TELEPHONE SERVICE EXTENDED

Siam

TRANSOCEANIC telephone service was extended to Siam on July 15, but for the present is limited to calls to and from a special call office in Bangkok. The rate for the initial three minutes is $45 between Bangkok and the first zone in North America, and the report charge is $5 in all cases. The hours of service are generally from 3 A.M. to 5 A.M. and from 8 A.M. to 9 A.M., Eastern Standard Time. Calls to and from Siam go by way of Germany.

Balearic Islands

On July 15 service was extended to the Balearic Isles. The rate to and from the first zone in North America is $36.75 and the report charge is $5.25. The hours of service are generally from 4:30 A.M. to 8:30 A.M. and 11:30 A.M. to 5 P.M., Eastern Standard Time. Transmission to the Balearic Isles is through the short wave station in Madrid.

Egypt

On August 8 service was made available between Cairo and Alexandria, Egypt and all Bell and Bell-connecting telephones in North America. A three-minute conversation between New York and either of the Egyptian cities costs $36, with $12 for each additional minute.

Egypt is reached over the regular transatlantic radio telephone channels operated by the American Telephone and Telegraph Company and the British Post Office, and a radio circuit between London and Cairo. The circuit distance from New York to Cairo is about 6,000 miles. Cairo, with a population

of 1,100,000, has some 17,500 telephones; Alexandria, with 600,000 people, has about 11,600.

Peru

On October 14 telephone service was inaugurated between North America and a number of cities in Peru. The service was opened by an exchange of greetings between officials of the United States and Peruvian governments in Washington and Lima.

The voice channel thus established links Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico with those of Lima, Callao and other Peruvian cities. These represent about 70 per cent of all telephones in that country. The charge for a three-minute call between New York and any of these cities is $30.

The channel between North America and Peru is formed by a radio circuit between American Telephone and Telegraph Company radio stations in New Jersey and those of All America Cables, Inc., at Lima. It is operated on short waves, employing a wave length of approximately 15 meters, corresponding to a frequency of about 19,000 kilocycles.

SERVICE PLANNED TO SEVERAL COUNTRIES AROUND THE CARIBBEAN SEA

RADIO telephone service from the United States will be extended to half a dozen Central and South American republics bordering on the Caribbean Sea by the end of this year, according to plans of the American Telephone and Telegraph Company. Furnishing the service will necessitate the establishing of a new radio station at Hialeah, Florida, near Miami. Equipment for the station has been ordered.

Among the new countries to be reached by the service is Panama, including the Canal Zone. The latter will be the second outlying possession to be connected with the United

States by radio telephone, as service with Hawaii was opened last December.

Other Central American republics included in the scope of the service will be Honduras, Nicaragua and Costa Rica. The South American countries to be connected are Colombia and Venezuela. The Bahama Islands will also be reached through the new station. With the proposed services in operation, the United States will have direct telephone connection with nearly all the countries and islands bordering on what was formerly known as the Spanish Main, as wire service already reaches Cuba and Mexico, and radio telephone service was extended to Bermuda late last year. The additions will bring the total foreign countries within telephone reach of the United States to forty-five.

Through arrangements with the Tropical Radio Telegraph Company, land and buildings owned by that company near Hialeah will be used to house the equipment which the American Telephone and Telegraph Company is installing for the new station. Due to the requirements of direction, location and distances, five sending and receiving antenna units will be set up, each operating with different distant countries.

In Panama City; Managua, Nicaragua; and Tegucigalpa, Honduras, the stations are owned by the Tropical Radio Telegraph Company. In San Jose, Costa Rica, the station is owned by the Compania Radiographica Internacional de Costa Rica; in Colombia by Marconi's Wireless Telegraph, Ltd.; in Venezuela by the Venezuelan Government and in the Bahamas by the Bahaman Government. Wire connections with the radio stations will be made through the telephone networks of the Compania Panamena de Fuerza y Luz, an affiliate of the Electric Bond and Share Co., in Panama; of the Compania Anonima Nacional Telefonos de Venezuela and of the Compania Telefonica Central, Colombia, both of which latter companies are affiliates of the Associated-General Telephone Group.

The Western Electric Company is supplying the equipment to be used in Florida and the transmitting and receiving units to be installed in Central America and the Bahamas. This equipment consists of seven specially designed short wave radio telephone transmitters and the same number of superheterodyne receivers. Distances to be covered by the voice waves range from less than 200 miles to Nassau, in the Bahamas, to more than 1,200 miles to Bogota and Caracas.

SHIP–SHORE SERVICE TO S.S. *REX*

ON OCTOBER 6 ship-shore service was extended to the S.S. *Rex*, 50,000 ton liner of the Italian Line, enroute to New York on her maiden voyage. This is the first vessel flying the Italian flag to have this service, which reaches a dozen other large liners.